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The Belmont Filtration Works.

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The Belmont works for filtering the water supply of West Philadelphia, embracing the 24th, 27th, 34th and 40th Wards, containing at the present time a population estimated at 170,000, are located on Belmont Avenue near the city line. The tract of land taken for these works contains 60·57 acres, lying partly north and partly south of Ford Road, between Belmont and Monument Avenues. Upon the land located north of Ford Road are placed the sedimentation and clear water basins, and on the land south of Ford Road are placed the plain sand filters and preliminary filters. Enough land south of the plain sand filters is unoccupied and reserved for the construction in the future of eight more filters of the same effective sand area as those now built.

The agitation of an improved water supply for West Philadelphia was a strong factor in shaping and promoting

the works which are now being constructed under the ordinances of Councils providing for the improvement, extension and filtration of the water supply.

As early as June, 1898, Councils passed an ordinance

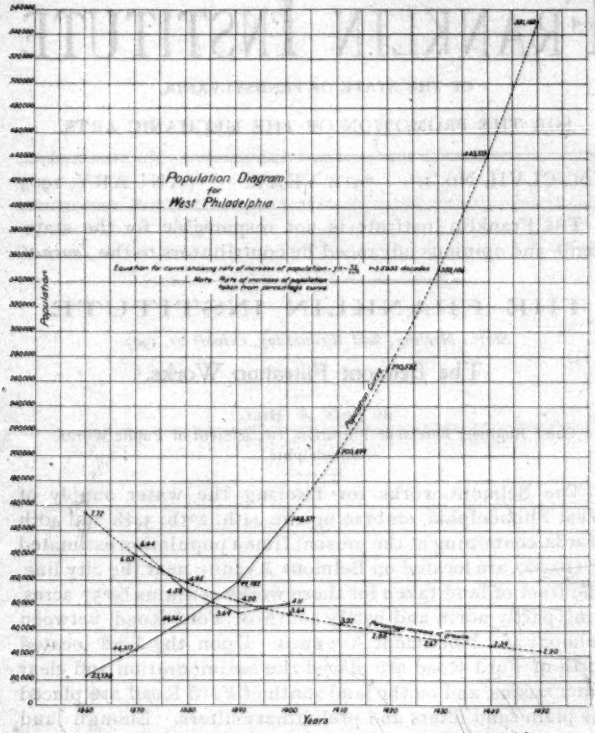

FIG. 1.—Diagram showing population of West Philadelphia.

appropriating $3,200,000 for the improvement of the water supply, and mainly through the exertions of Hon. Edward W. Patton, member of Councils from the 27th Ward, a provision was incorporated in the ordinance that at least

$500,000 of this amount should be applied to the improvement of the Belmont Works. The actual outlay for West Philadelphia, including land and the extension of the pipe-distribution system, will be over $4,000,000.

POPULATION.

West Philadelphia, as shown by the census enumerations from 1860 to 1900, inclusive, has been growing at a greater rate than that portion of the city lying between the Delaware and Schuylkill Rivers, and as a preliminary step in determining the capacity of the works of filtration required for the present and future supply of this section of the city, a careful study of the past and prospective growth of population was made.

By inspection of the diagram (*Fig. 1*) it will be seen that from a population of 23,738 in 1860, it has grown to 148,371 in 1900, and by plotting the mean annual rate of growth for each census decade, and drawing a smooth curve through the points on the diagram, the smoothed rates of growth from 1860 to 1950, stated as the mean annual increase, are as follows:

	Per Cent.
1860	7·72
1870	6·03
1880	4·95
1890	4·20
1900	3·64
1910	3·22
1920	2·88
1930	2·63
1940	2·39
1950	2·20

Corresponding to the following future populations:

1910	203,699
1920	270,582
1930	350,106
1940	443,373
1950	551,162

Upon a basis of 150 gallons of water per capita per day the consumption of water for each ten years of the next five decades should run about as follows:

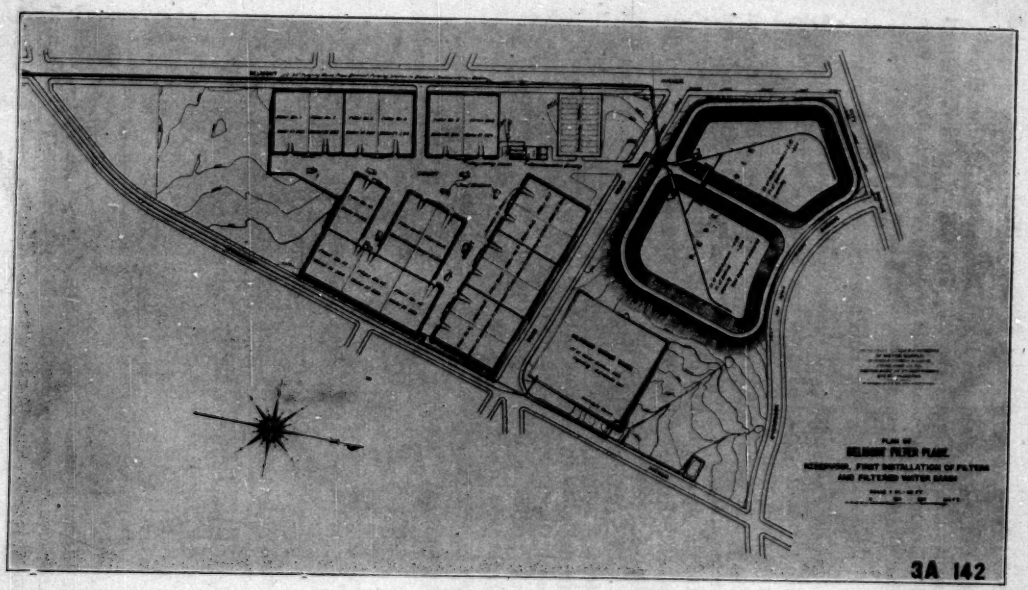

FIG. 2.—Belmont filters and reservoirs.

	Gallons Per Day.
1910	30,554,800
1920	40,637,300
1930	52,515,900
1940	66,506,000
1950	82,674,300

The present consumption of West Philadelphia is, as an average, 185 gallons per capita per day, and if steps are not taken to reduce the unnecessary and avoidable waste of water, the consumption by 1950 will reach over 100,000,000 gallons per day, or about the ultimate capacity of the Belmont works.

In the report of the Expert Commission appointed by Mayor Samuel H. Ashbridge, May, 1899, it is stated that the least flow of the Schuylkill River has been shown to be about 150,000,000 gallons in twenty-four hours, and that it was thought prudent to not exceed this quantity as the maximum daily consumption of water from this source.

Apportioning this consumption of Schuylkill River water between West Philadelphia and Roxborough, it has been assumed that if the present rate of consumption is maintained, these two districts will require respectively 100,000,000 gallons and 50,000,000 gallons per day within the next fifty years—the entire allowable quantity which, according to the experts' report, should be drawn daily from the Schuylkill River.

PRINCIPAL DETAILS.

The Belmont Works consist of two subsiding basins, each containing at flow line about 36,000,000 gallons of water, which, at the present rate of consumption, represents 2·40 days' sedimentation of the water before it is drawn from the basins; eighteen plain sand filters, in part modeled after the filters at Berlin, Warsaw and St. Petersburg, and in part after the newer filters at Hamburg; a system of preliminary filters adapted at a rate of 80,000,000 gallons per acre per day, to deal with 40,000,000 gallons of water daily, and a clear water basin, 15 feet in depth, with a capacity of 16,500,000 gallons; eight hopper sand washers, patterned after the washers in use at the Hamburg filters; an admin-

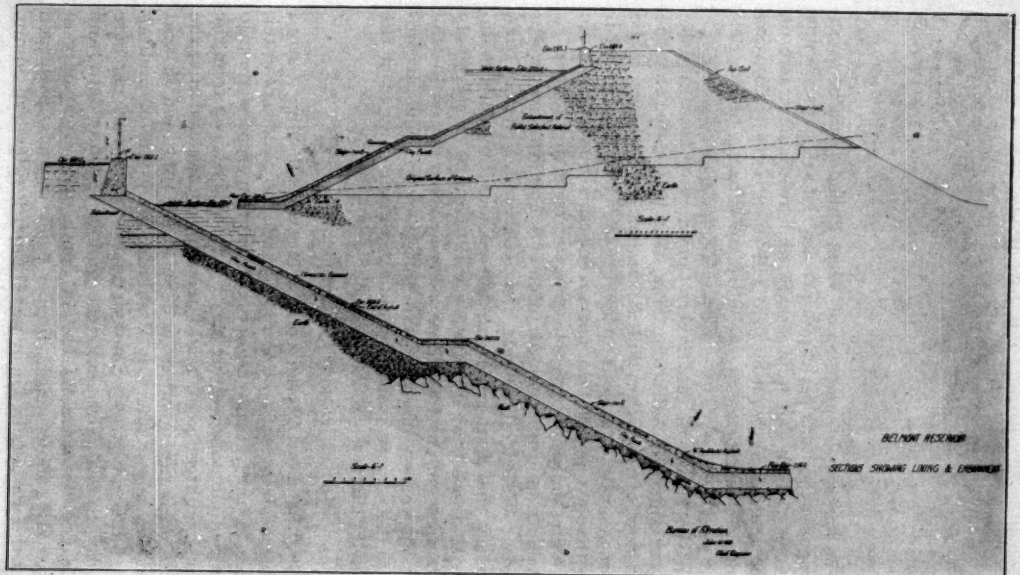

FIG. 3 —Section through embankment of sedimentation reservoirs.

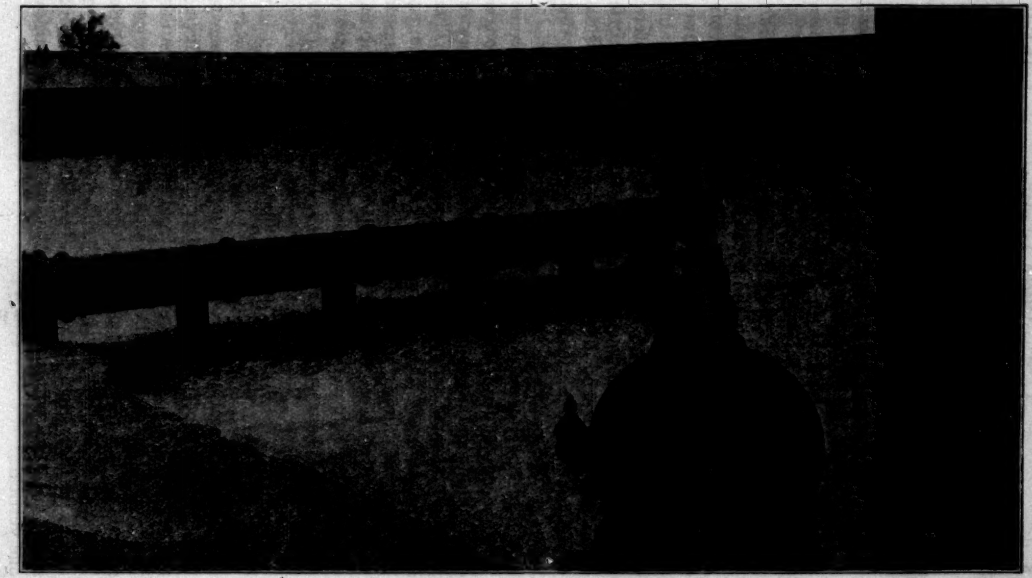

FIG. 4.—Sedimentation reservoir. East division.

istration building and pumping station; centrifugal pumping machinery to supply wash water to the preliminary filters; direct acting plunger pumps to supply water under pressure to the sand washers; steam boilers for power and heating the buildings, and an electric lighting equipment.

Considering the chief features of the works, *Fig. 2* shows the location of the sedimentation reservoir, preliminary filters, plain sand filters, the clear water basin and the administration building.

Belmont Avenue, as will be noticed from the meridian symbol, has a nearly north and south direction. With this explanation it will be seen that the sedimentation reservoir occupies the land bounded on the west by Belmont Avenue, on the north by City Avenue and Overbrook Avenue, and on the south by Ford Road. The preliminary filters are located at the intersection of Belmont Avenue and Ford Road. The plain sand filters are located along the east side of Belmont Avenue, the south side of Ford Road, and the west side of Monument Avenue, and the clear water basin at the intersection of Ford Road and Monument Avenue. The unoccupied land, which is shown with contours south of the plain sand filters, is reserved for an addition of eight filters of the same general dimensions as those shown. The small rectangles, of which there are eight, shown in the court between the filters, indicate the location of the sand washers. Between the preliminary filters and the group of six filters on Belmont Avenue is placed the administration building and boiler and pump rooms.

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SEDIMENTATION RESERVOIR.

(Contract No. 16.)

The sedimentation reservoir consists of two divisions, or basins, each 25 feet deep, measured at the flow line, elevation, 279·00 C. D., and 29 feet deep from the top of embankment, elevation 283·00 C. D. The area of the east division at the flow line is 5·43 acres, and at the floor line 3·47 acres. The area of the west division at the flow line is 5·33 acres, and at the floor line 3.037 acres. The inside and outside slopes are, at all points around the basins, two horizontal to one vertical.

Top width of embankment, 18 feet; width at toe of inner slope, 134 feet. The east division was constructed about equally of cut and embankment, while the west division, excepting the embankment along Ford Road, was nearly all in excavation, some of which was quartzlike trap rock. The materials of excavation consisted of clay, micaceous rock, sand, gravel and hard rock, the latter requiring drilling and blasting for its removal.

In making embankments, the best materials of excavation were placed next the inner slope, and all materials were rolled in thin layers. When the excavation in rock discovered fissures, these were filled with grout, and the irregular surfaces of the rock in the floors, and slopes leveled up to sub-grade partly with concrete and partly with clay puddle.

In preparing the ground for rolled embankment for the sedimentation reservoir the top soil was first thoroughly stripped off and the inclined ground stepped in horizontal terraces.

The reservoir embankments and the fill under the filters on Monument Avenue were rolled with four 25-horse-power traction engines weighing 10 tons each, or 3,300 pounds per foot width of roller wheels, two 18-horse-power traction engines weighing approximately 8 tons each, or 3,000 pounds per foot width of roller wheels, and one 10-ton traction roller, manufactured by the Julius Scholl Company of New York. All rollers were grooved.

In the original plan of the reservoir, as shown in *Fig. 3*, the inner slopes were constructed with a berm at an elevation of 12·7 feet above the finished floors of the basins, and the upper slope set back a distance of five feet to receive a granite block paving to be set dry, and backed with broken stone. This was intended as a protection to the puddle lining from frost, but further consideration of this feature of the construction raised doubt of its utility, and it was omitted in finishing the basins. Each division of the reservoir is lined on the floor and slopes with 18 inches of clay puddle, on which is placed a 6-inch course of concrete. On the concrete to within a vertical depth of 10 feet from the water line is placed a ¾-inch mixture of asphalt, asphaltic

mastic and grit. *Fig. 8* shows the height on the slopes of the asphalt lining.

In the division wall between the two basins, which is constructed partly in excavation and partly of embankment, are placed two equalizing or pass pipes, which, when the valves are opened, maintain a uniform elevation of water surface in both divisions of the reservoir. Each of these pipes is supplied with a floating inlet pipe, which receives the water at the surface of the reservoir and conducts it to the pass pipe and thence to the opposite side of the division wall, where it is discharged at the bottom of the basin. The equalizing pipes, and the influent and effluent pipes, are placed in trenches provided with concrete cut-off walls, the spaces between which, under, around and over the pipes, are packed with well-rammed puddle.

Fig. 4 shows the 48-inch diameter influent pipe in the east division of the reservoir, into which is connected, at the angle near the center of the basin, the equalizing pipe from the west division of the reservoir. The influent pipe crosses the basin diagonally from the southwest to the northeast corner, and terminates in a set of fourteen 48-inch tees and one 48-inch elbow, with the branches turned slightly upward from the horizontal, as shown. The line of pipe and special castings are supported on low brick piers set on the asphalt lining of the floor. By means of the arrangement of shown pipes, the water from the Schuylkill River at the Belmont Pumping Station is passed diagonally from end to end and from the bottom to the surface of the water in each division of the sedimentation reservoir. It is thus hoped that currents having a tendency to carry the heavier suspended matter out of the reservoir, will be avoided.

In the line of each influent pipe is placed a 48-inch check valve, made by the Ludlow Valve Company of Troy, New York. Each of these check-valves weighs about 32,000 pounds.

The subsided water is conducted from either division of the reservoir to the screen-chamber, and thence to the preliminary filters through floating pipes, one of which is shown lying on the floor to the left of the effluent chamber in

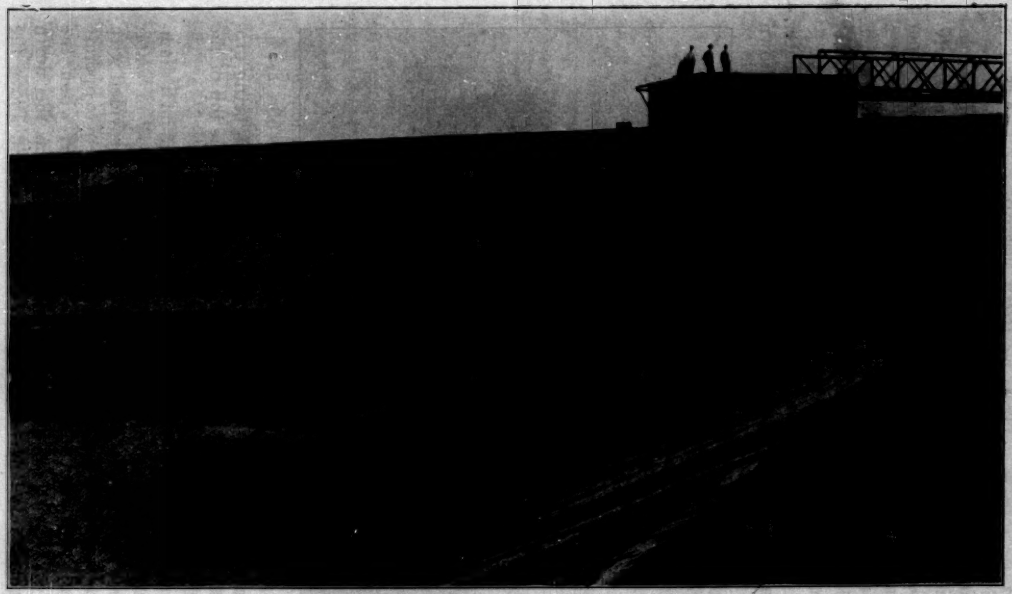

FIG. 5.—Screen chamber and floating pipes.

Fig. 5. This pipe, 48 inches diameter, is made of galvanized sheet-iron, attached at the lower end to a 48-inch swiveling tee, mounted in bronze bearings, and at the upper end by flexible connections to a float which consists of a galvanized sheet-iron, water tight cylindrical barrel, which allows the mouth of the pipe to be submerged a few feet below the surface of the water.

Should the floating pipe for any reason fail to act, water can be drawn through either of the three sluice gates shown

FIG. 6.—Sedimentation reservoir. Gate-house.

on the inside face of the effluent chamber, each being provided with a compound geared gate-stand on the top of the effluent chamber.

In the gate-house, *Fig. 6*, are placed eleven 48-inch diameter Ludlow stop-valves, which control the flow of water into and out of the reservoir, each of which is provided with a compound geared gate-stand and extension stem to operate from the floor of the house. The gate-house, when the works are completed, will have a frontage on the north property line of Ford Road sufficiently elevated above the

grade of the street to make a neat and pleasing feature of the works.

The plan of the influent and effluent pipes where they pass through the gate-house, is such that the raw water may be delivered entirely into one division of the reservoir and drawn from the other; or may be delivered into and drawn from each division at the same time; or one basin can be cut out of service entirely; or one of the two supply pipes entering the gate-house from the left, will supply into both or either division of the reservoir, and likewise the subsided water can be directed into either of the two lines of 48-inch effluent pipes shown at the bottom of *Fig. 7*.

The two lines of rising pipe which bring the water from the Belmont Pumping Station to the gate-house are each 36 inches in diameter.

In the upper part of the gate-house is constructed a room for the reservoir watchman, access to which is had by means of a spiral iron staircase.

All the joints in the gate-house, excepting the last joint in each line of pipe, are made with flanges and bolts and gaskets.

PRELIMINARY FILTERS.

(Contract No. 38.)

Fig. 8 shows in place the first installation of preliminary filters, placed in the center of the ground lying between Ford Road on the north and plain sand filter No. 6 on the south.

South of the first installation of filters, ground is reserved for an addition of 25,000,000 gallons daily capacity, and north of the first set of filters, space is left for a further addition of 30,000,000 gallons daily capacity, or an ultimate aggregate daily capacity of 95,000,000 gallons.

In the arrangement of the 48-inch main pipes to conduct the water to and from the preliminary filters, provision has been made for the necessary influent and effluent connections to the future installations, and to admit of these connections being made without interrupting the service of the first set of preliminary filters.

Connection of the two 36-inch rising mains in Belmont

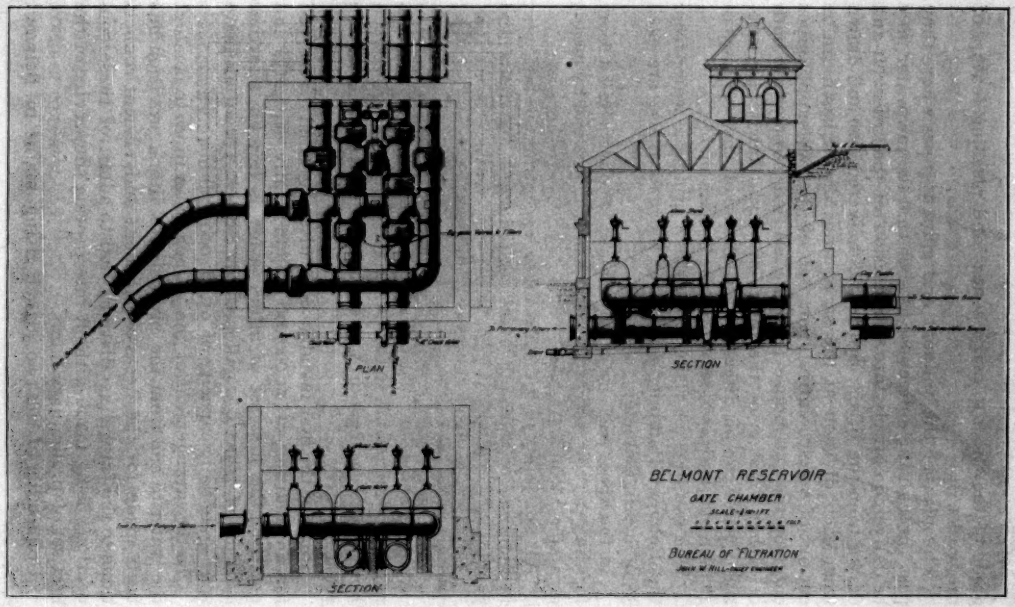

FIG. 7.—Sedimentation reservoir. Section through gate-house.

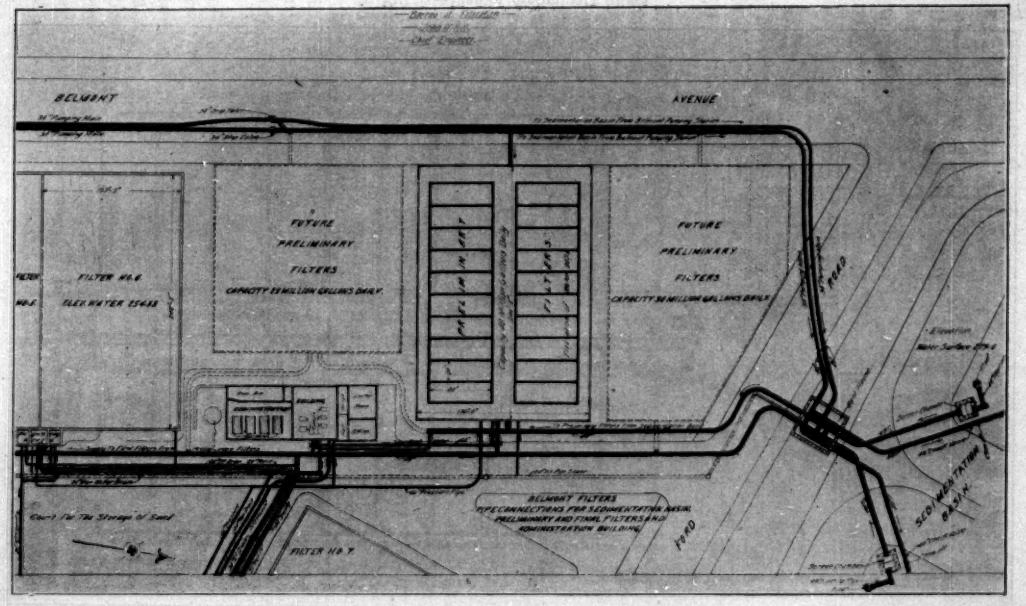

FIG. 8.—Influent and effluent pipes. Preliminary filters.

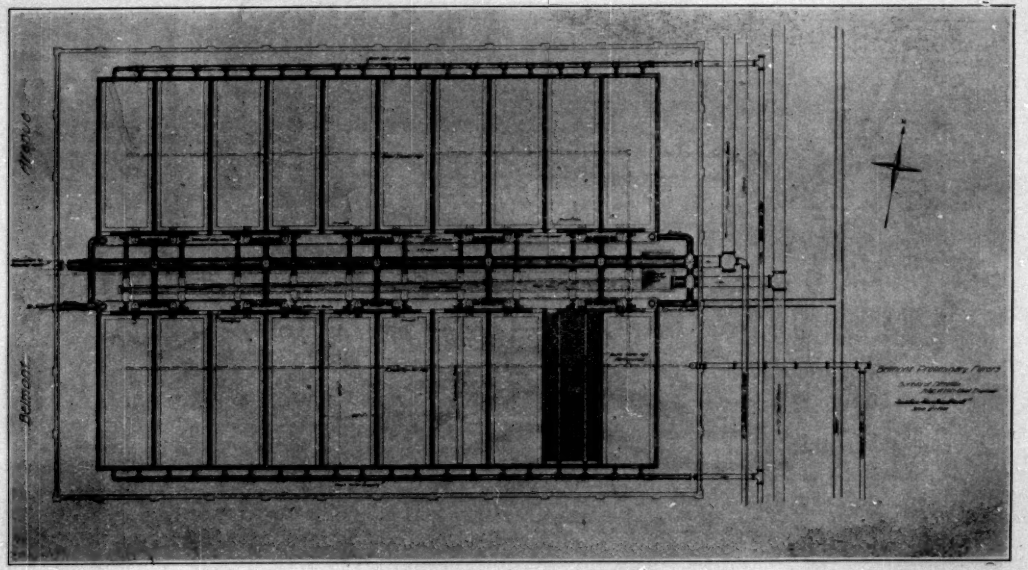

FIG. 9.—Plan of preliminary filters.

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Avenue with the main influent pipe of the preliminary filters, is also made to admit of the pumping of water direct to the filters at any time when it might be necessary to take the sedimentation reservoir temporarily out of service. Likewise, if for any reason it might become necessary to take the preliminary filters temporarily out of service provision has been made to draw water direct from the subsiding basins to the plain sand filters.

As a measure of economy in the operation of the works, and to attain the highest possible efficiency in filtration of the water, the system of operation should consist of limited subsidence in the sedimentation reservoir, preliminary filtration, and final filtration.

The preliminary filters, as planned by the Bureau of Filtration, *Figs. 9* and *10*, consist of twenty concrete tanks each 60 feet long, 20 feet wide, 8 feet 6 inches deep. In the bottom of each tank is first placed 12 inches of gravel, ranging in size from 2½ inches to ¼ inch in diameters, and above this a layer of 30 inches of coarse sand, consisting of grains which will pass a No. 6 sieve and be retained on a No. 30 sieve. Such sand will be coarser and of more nearly uniform grain than that used in the plain sand filters.

The water from the subsiding basins is introduced at the top of the filter and percolates at a high rate downwards through the bed of coarse sand to the layer of underdrain gravel at the bottom, through which it flows in many streams to a main collector placed in the center of the filter, and thence out of the filter over a measuring and regulating weir to an open duct built of concrete, which in turn conducts the rough filtered water to the 48-inch cast-iron supply pipe of the plain sand filters.

At the level of the gravel under-drains is placed a system of wash pipes consisting of two lines of 12-inch main pipe, from each of which 2-inch branch pipes placed on 8-inch centers extend right and left under the sand bed to the opposite main pipe and side walls of the tank. The main pipes and branch pipes are perforated on the upper side. Water under a head of fifty feet will be used to wash the sand bed by reverse current, or rather by forcing the wash water from

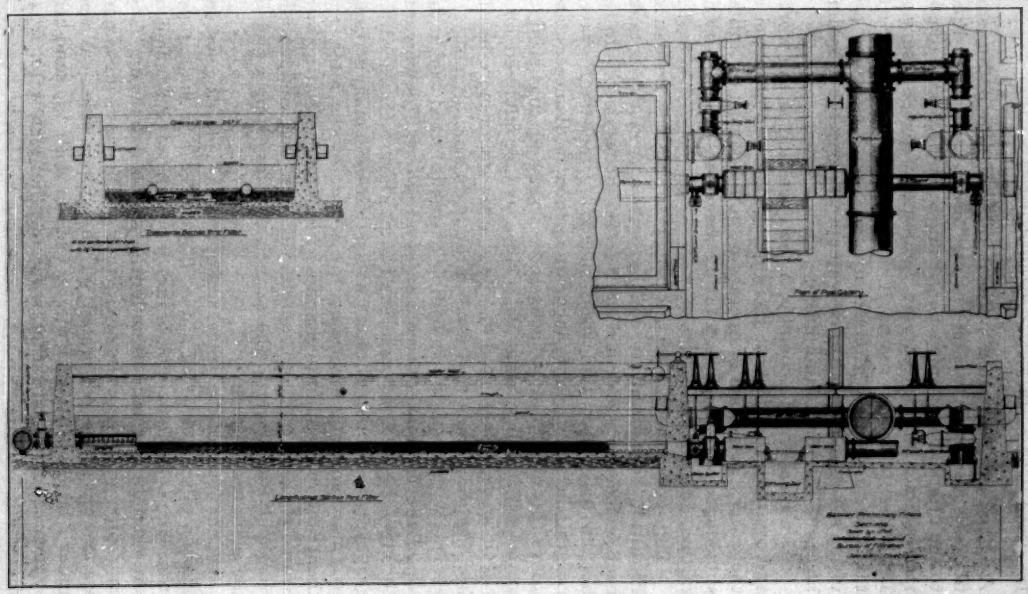

FIG. 10.—Section through preliminary filters.

below upwards in the same manner as in several types of the mechanical filter, excepting that the wash-water pipes are not effluent pipes, as they are in the mechanical filter when operating under normal conditions. Overflow troughs are placed around the filter tank at an elevation about 12 inches above the level of the sand bed, adjustable as to height. These troughs receive the wash water and conduct it out of the filter to a waste gullet of concrete placed in front of the filters.

From an experience of eighteen months with an experimental mechanical filter, 10 feet diameter, at the Spring Garden Testing Station, in use for part of the time without agitation of the sand bed with rakes or by other means, it is thought that mechanical agitation of the sand bed of the preliminary filters while washing is not essential, and that a washing daily, or as often as the loss of head in the operation of the filter may show to be necessary, with the occasional removal from the tank and washing of the sand in hopper washers, will restore the sand bed to its normal condition at less cost of operation and with less chance of interrupting the work than by the use of mechanical agitating devices, or with agitation by means of compressed air.

The principles of construction and operation of the preliminary filters are essentially the same as that of the plain sand filters, excepting the filtering materials are coarser and the sand bed will not be scraped periodically, but washed by a current of water from below upwards daily, or as often as may be required, and the rate of percolation will be maintained at about fourteen times the rate af percolation adopted for the plain sand filters.

The purpose of the preliminary filters at Belmont, and at the other works forming part of the improvement of the water supply, is three-fold: Primarily to enable the plain sand filters to operate at a higher rate than has heretofore been employed and correspondingly reduce the acreage of filter surface required to treat the whole water supply. Next, to prolong the life or rather to increase the yield of the plain sand filter between scrapings from 60,000,000 or 70,000,000 gallons per acre to from 90,000,000 to 150,000,000 gallons per acre,

and finally to maintain a more regular effluent than is possible with the plain sand filter when supplied with water which has been under either quiescent or continuous subsidence for a day, or for a few days.

The preliminary filters are intended to perform in a short time what could be accomplished only in a very long time by sedimentation reservoirs.

The capacity of the Belmont preliminary filters is based upon a rate of percolation equivalent to 80,000,000 gallons per acre per day, and at this rate nineteen of the twenty tanks will each furnish 2,200,000 gallons of rough filtered water, or pre-filtered water, per day.

In the operation of the preliminary filters, one filter containing only the gravel and underdrains will always be out of service, so that, when either of the filters becomes clogged with "mud balls" so as to demand a washing of the filter-sand, this sand will be thrown out of the filters by means of the ejector (presently to be described in connection with the removal of sand from the plain sand-filters) into a three-hopper ejector-washer and delivered from the washer into the empty filter. Thus it will be seen that the sand in transportation and washing will be worked from filter to filter, and, excepting at such times when one filter will be out of service for washing, and one filter receiving the washed material, there will always be nineteen filters in service. It is estimated that it will require about eight hours to remove and wash the sand and replace it in the empty filter. When the operation of washing by the hopper-washers has been performed, the sand will then be in the same condition it was when the filter was first started in service.

Experience at the Spring Garden Testing Station has shown that even with the addition of the revolving rake agitator the reverse current of water is not capable of thoroughly washing and preventing the formation of some "mud balls" in the body of the sand, excepting with a wasteful expenditure of water, and it is anticipated that the cost of prefiltering the water, including the washing and transportation of the sand by means of the sand-ejector and

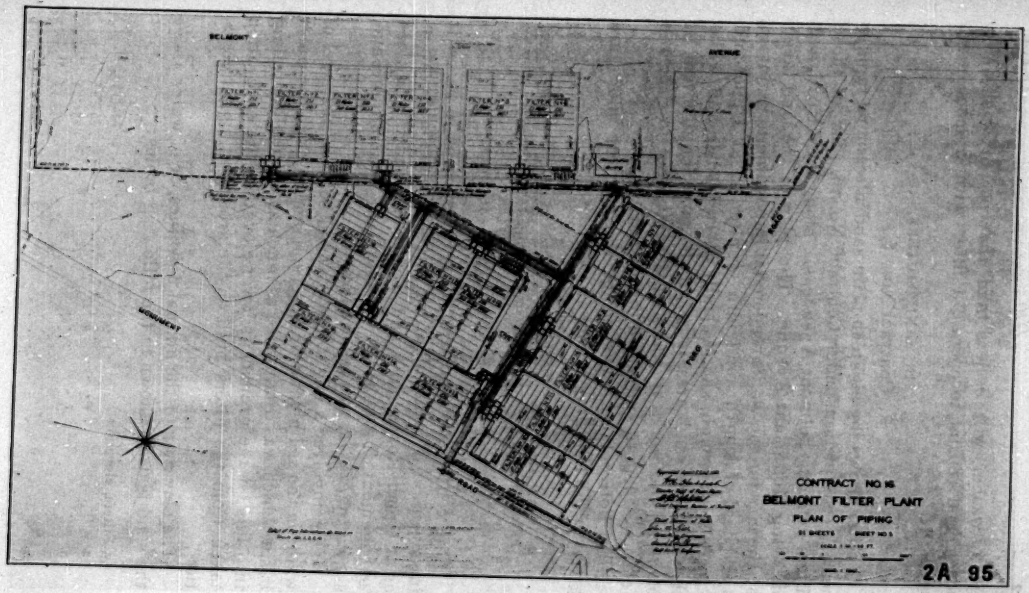

FIG. 11.—Plan of plain sand filters.

ejector-washer, will be less than the cost of wash-water power and repairs to operate a filter with a mechanical agitator.

PLAIN SAND FILTERS.

(Contract No. 16.)

Fig. 11 shows the eighteen plain sand filters now rapidly nearing completion under Contract No. 16. Six of these filters lie along Belmont Avenue, six along Ford Road, and six along Monument Avenue. The plan of the land taken by the city for the works rendered it impossible to maintain a standard of length and width of filter, as at Upper and Lower Roxborough, and generally at Torresdale, and, while the effective sand area is about the same for all filters, in planning the works it was found convenient to vary the relation of length and width to suit the ground.

The horizontal dimensions of the eighteen filters are given in the following table:

DIMENSIONS OF FILTERS.

7	Filters	. . . . .	242	feet	2	inches	long,	135	feet	5	inches	wide
8	"	. . . . .	272	"	8	"	"	120	"	2	"	"
3	"	. . . . .	196	"	5	"	"	165	"	11	"	"

The contours of the land also was such as to make it inconvenient to locate all of the filters at common elevation, as at Upper Roxborough and Torresdale, and the terraced arrangement, through the six filters on Belmont Avenue, shown by *Fig. 12*, was resorted to.

This involved a slight loss of head between the level of water in the sedimentation reservoir and in the clear-water basin, which was diminished as much as possible by rolling into fills on the ground at lower elevation, the excavation taken from the filters built on the ground at higher elevation.

The elevation of the normal flow-lines, or of water above the sand beds, is shown in the following tables:

5	Filters, elevation	. . . . .	248·33	C. D.
2	"	"	250·33	"
5	"	"	251·33	"
2	"	"	252·33	"
4	"	"	254·33	"

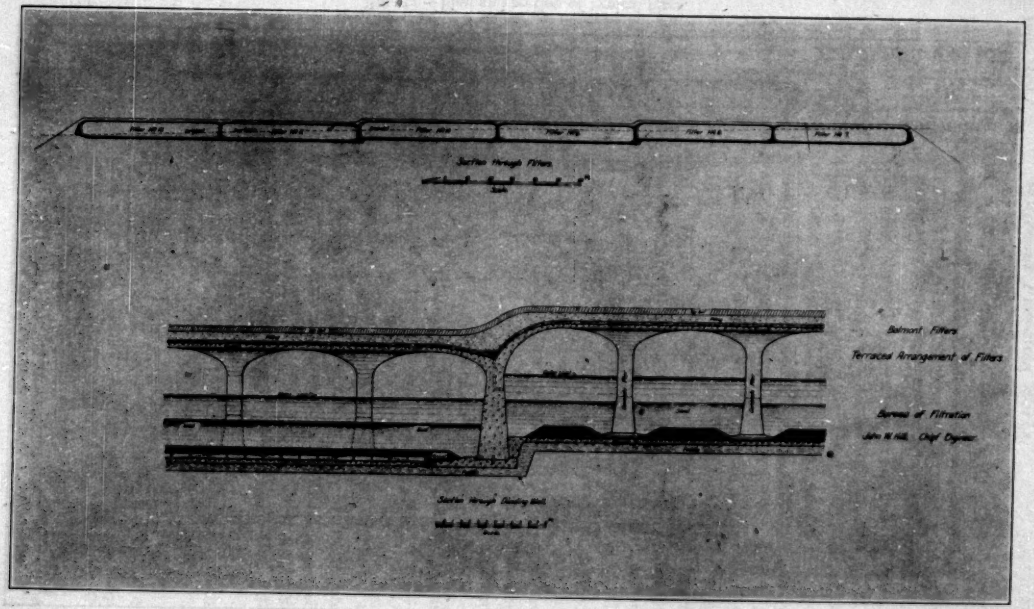

FIG. 12.—Section showing terrace arrangement of filters.

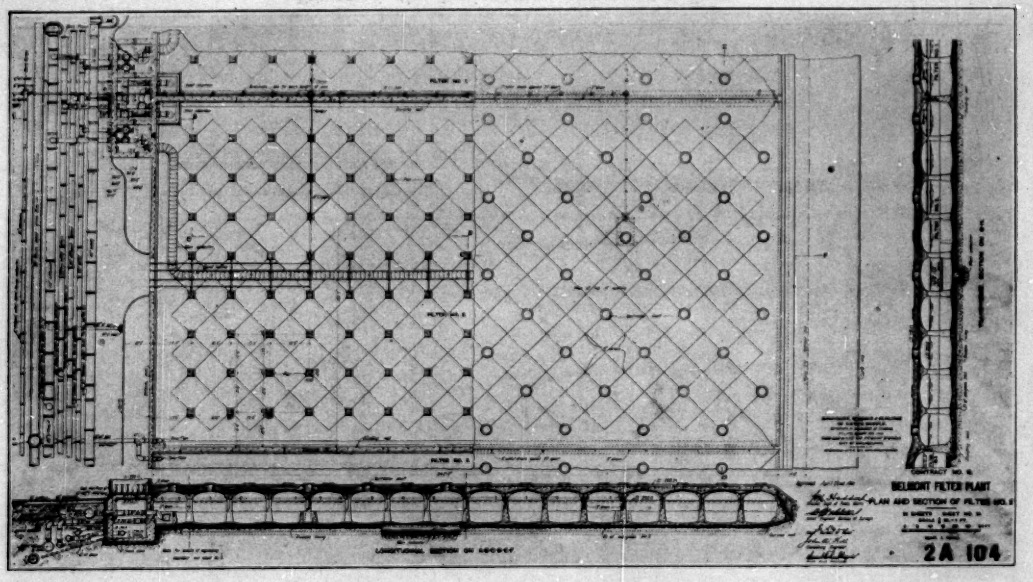

FIG. 13.—Plan and section of typical filter.

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Difference of water surface between the highest and lowest filter, six feet.

Since the level of water in the clear-water basin (for any system of terraced filters) must be adjusted to the flow-line of the lowest filters of the series, the apparent loss of head at Belmont is six feet; but to attempt the placing of all filters at a common elevation would have required the raising of the fills under the filters at the lower levels, the materials for which could conveniently be obtained only from the excavation for filters at the higher levels, and the resulting common level of water surface in all filters would have been only about three feet higher than the water-level in the lowest level filter of the present series. This, therefore, is the true loss of head, against which the water is pumped from the Schuylkill River by reason of the terraced arrangement of filters at Belmont. That is to say, if all filters had been arranged at common water elevation, 251·33 C.D., the flow-line of the sedimentation reservoir might have been made 276·00 C.D., instead of 279·00 C.D.; but the fixed charges on the increased cost of construction to accomplish this were found to be much greater than the annual cost of pumping against the additional three feet head.

The plain sand filter at Belmont, as shown by *Fig. 13*, is in plan a rectangle with a net area at the sand line of 0·735 acre.

By the longitudinal section through the filter it will be seen that the roof arches are carried on monolithic concrete piers 30 inches square at the base and 22 inches square at the top of the battered portion of the pier. The battered section reaches to the proposed normal sand line. The side and end walls have a width at base of 4 feet 2 inches, and at spring line of arch a width of 1 foot 10 inches. Division walls have the same dimensions in thickness as the piers.

The floors consist of concrete inverts 15 feet 3 inches square, having a thickness of 6 inches at the center and of 14 inches under the piers. The vaulting of concrete is 6 inches thick at the crown, and normal to the arch curve about 15 inches thick at the spring line. The piers are 9 eet 1 inch high, the rise or depth of arch of floor inverts at

center 8 inches, and rise of roof-arch at center 36 inches, making a total height from center of invert to center of soffit of arch 12 feet 9 inches. The clear span of roof-arches is 15 feet 5 inches.

Under the floors and against the side and end walls of the filters, taken in groups of two, four, and six, clay puddle is placed as shown. The floor puddle was placed and rolled in two separate layers, each of 6 inches thickness when rolled in place. The puddle around the filters was carried 1 foot higher than the nominal water line in the filters, and rammed in layers of from 4 to 6 inches in thickness. (The value of the puddle as a means of insuring watertightness of the filters will be shown hereafter.)

The end walls of all filters, and side walls of the end filters, were designed as abutments to transmit the arch thrust to the foundations.

Each alternate bay of the filter is provided in the roof-arch with a round ventilator opening 36 inches in diameter. This is closed with a double iron plate cover, forming an air space between the two plates to prevent the frost from acting on the water or on the bared sandbed while it is being scraped in winter. In summer time it is desirable to have some of the ventilators open to prevent the air in the filters from becoming musty by the decomposing sewage solids intercepted at the surface of the sandbed. With open filters the musty condition of the air over and around the filters is not noticed, but with closed filters, excepting ventilation is provided, the air over the water becomes saturated with the gases of decomposition of sewage solids intercepted at the surface of the sandbeds, and ventilation is a necessity for the comfort and possibly for the health of the men required to enter the filters for scraping and removal of the fouled sand.

Over the arches of the filters at the crown a layer of 24 inches of earth is placed to protect the water and sandbed, when laid bare, from frost in the winter and to protect the water from the sun's rays in summer. At the depressions in the arches over the piers is placed gravel or ballast to act as a "French" drain and collect the water from rainfall which

may percolate through the earth filling over the vaulting and pass it down to the filter through the opening left in the haunch of the arch. The upper surface of the earth filling is finished with a dressing of top soil and seeded. In due time the surface of the fill will have a turf which, if kept properly watered and trimmed, will make a pleasing feature of the landscape.

Six lines of cast-iron waterpipe are shown to the left of the filter, arranged as follows:

Influent pipe to supply water to the filters.

Effluent pipe to conduct away the filtered water.

Refill pipe to refill filters from below with filtered water after scraping the sandbed.

Raw-water drain pipe to draw off the water from above the sand line.

Drain pipe to draw off the water from below the sandbed and conduct it to the sewer.

High-pressure pipe to supply water to the sand ejectors, and also to the sand washers in the courts.

In addition to the cast-iron pipes enumerated a 36-inch circular brick sewer, for waste water from the filters, and from the sand washers, and storm water collected on the courts, is also shown.

At Belmont (with the exception of two filters) the regulator houses are arranged each to serve two adjacent filters. (See *Fig. 14.*) The well or chamber under the regulator house is divided into a middle dry chamber and two side wet chambers. In the middle chamber are placed the pipes, stop-valves, and special castings, which connect the main influent and high-pressure pipes with the filters, the raw water drain to remove the water from above the sand line, and, as shown, near the bottom of the chamber, the main effluent pipes, which originate in the side chambers, and are brought together into a tee at the center of the dry chamber. The influent and effluent pipes for each filter are provided with stop-valves to cut either out of service without interfering with the adjacent filter.

In the wet chambers are placed the effluent pipes, drain-pipes to remove the water from below the sandbed and

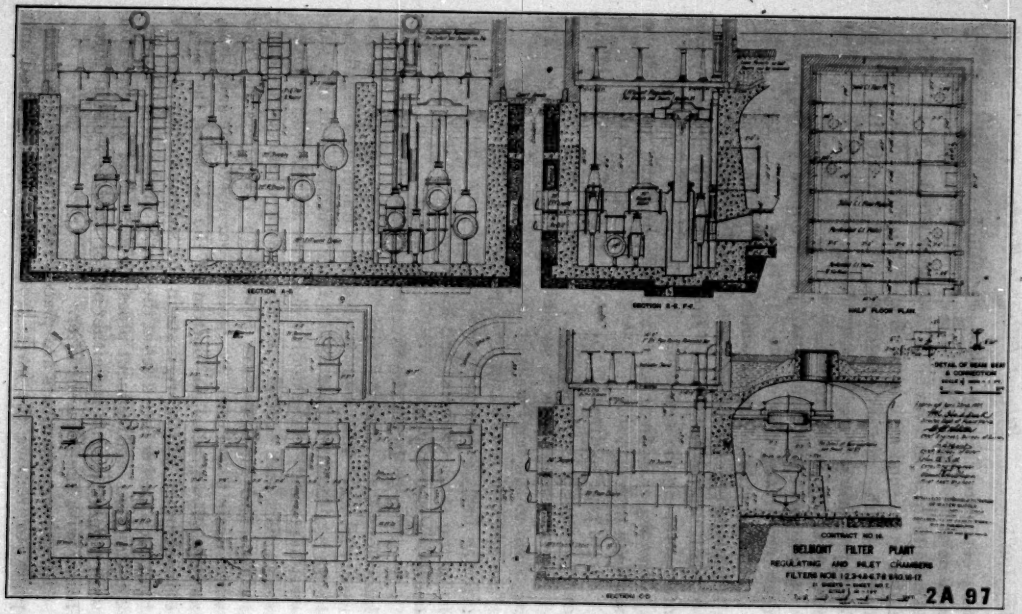

SECTION A-B
SECTION C-D
HALF FLOOR PLAN
DETAIL OF BEAM END & CONNECTION
CONTRACT NO 16
BELMONT FILTER PLANT
REGULATING AND INLET CHAMBERS
FILTERS NOS 1 2 3 4 5 6 7 8 9 10 11 12
SECTION C-D
2A 97

FIG. 14.—Influent and effluent chambers.

waste it to the sewer, and the re-fill pipe to supply water to the filter from below upon starting after a filter has been scraped.

Upon the main effluent pipe where it starts in the wet chamber, is placed an automatic telescoping circular weir, controlled in position with reference to the surface of the water in the chamber, by an annular copper float. This self-adjusting weir (which has its counterpart in the effluent chambers of the filters at Warsaw, Zurich, Bremen, and other places abroad) has its lip fixed at a definite depth below the surface of the water, and is not only an effective device to maintain a constant rate of flow of water from the filters, but when properly standardized becomes a reasonably accurate meter for the measurement of the flow.

The relation of the lip of the weir to the position of the float is adjustable, and it thus can be varied to produce any desired rate of percolation through the filter.

In the early form of the effluent weir the telescoping joint was made with a water-packed bronze gland; but experience at Roxborough has shown that it is impossible to produce drawn-brass pipes, 20 inches in diameter, so round or uniform in diameter as to admit of the use of the packing shown, and a leather packing, which will readily adjust itself to the eccentricity of the sliding tube and to the inequalities of diameter, has been substituted for the internally grooved bronze ring. The leather packings have worked admirably on the effluent regulators of the Roxborough filters, and, with the weir floating upon a constantly declining water surface, maintain, when adjusted, a practically unvarying rate of discharge from the filters.

Some trouble has been experienced from the air which is drawn into the column of water descending the telescoping pipe, and to remedy this defect in the construction of the regulators the necks at the top of the fixed barrels of the regulators are being tapped and provided with pipes reaching to a few inches above the highest possible water level in the effluent chamber, to vent the air from the regulator barrel. A test of one of these air-vents at Upper Roxborough

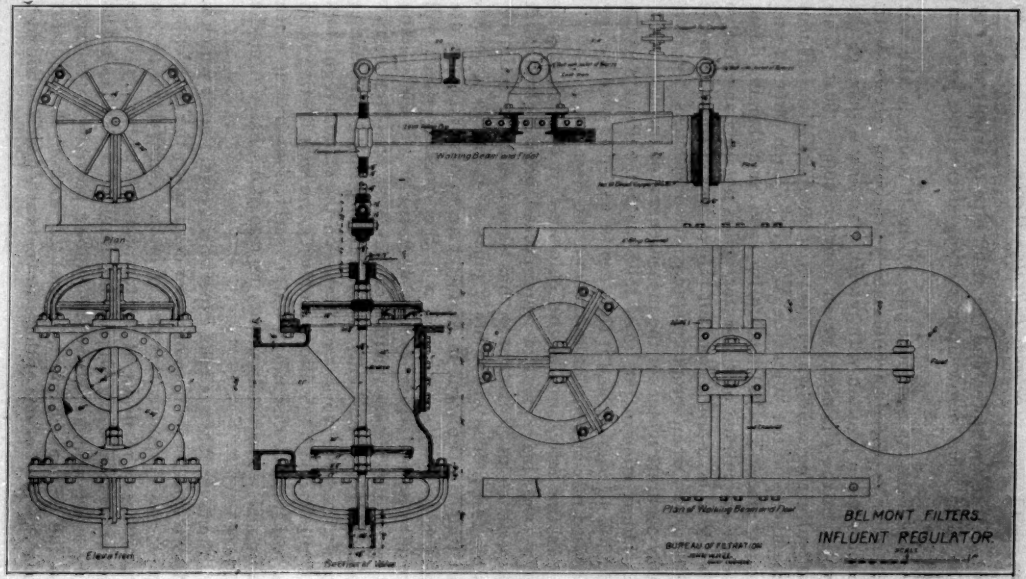


FIG. 15.—Automatic influent regulator.

seems to indicate that the trouble due to induction of air by the annular column of water flowing over the lip of the weir and down the telescoping pipe will be avoided in this manner.

The sleeve, or jacket-pipe, outside the telescoping pipe is used to prevent the current of water flowing from the regulator from having a tendency to draw the telescoping pipe from its central position, and cause it to bind in the packed joint.

Inside the filter on the end of the branch from the influent main is placed an influent regulator (*Fig. 15*) to automatically maintain a constant depth of water over the sand-bed. This consists of a plain double-seat disc-valve, nearly balanced, actuated by a cylindrical copper float. By the rise and fall of the float on the water in the filter the valve is closed or opened and the rate of inflow of raw water maintained nearly constant. This valve is in all material respects a copy of the influent regulators used on the Hamburg filters.

[*To be continued.*]

USE OF PEAT GAS IN IRON MAKING.

The use of peat gas for fuel purposes is of long standing in the iron and steel industry of Sweden, in which it is preferred to coal gas, on account of its much greater freedom from sulphur and phosphorus. At the rolling mills peat gas is used in the plate furnaces with the result of reducing the formation of scale, particularly in rolling thin steel plates. The use of peat gas has contributed largely to improving the quality of Swedish steel.

Peat, like wood, particularly green wood, is naturally suited, on account of its large percentage of moisture, to steady production of mixed gas, rather than to the alternate generation of first water-gas and then producer-gas, as with dry fuels such as coal.

POLONIUM.

Mme. Curie, the discoverer of polonium, maintains that it is not yet decided whether polonium is an element or not. The supposition that any radio-active substance which has different properties from other radio active substances is a separate element was verified in the case of radium, but is rendered uncertain by the phenomena of induced radio-activity. The case of polonium is rendered doubtful by the fact that the spectrum shows only the rays

of bismuth. On the other hand, it is possible to concentrate the radio-active substance contained in "radio-active bismuth," and this would not be possible if bismuth alone were present. Also, on sublimating bismuth sulphide, the sublimated portion is the more radio-active. It is possible that polonium does not possess any sensitive spectroscopic reaction. A serious point is the gradual loss of activity, which in one case amounted to 50 per cent. in eleven months. But Marckwald has succeeded in obtaining a polonium preparation which does not show any sensible loss. It would be interesting to determine the atomic weight of the element, and this the authoress is working at whenever she has a sufficient quantity of radio-active bismuth available.—*Physikal. Zeitschr.*

HIGH-SPEED ELECTRIC TRACTION.

The *Electrical World* has the following comments on the recent trials at Zossen:

Each new week sees a new record made at Zossen, in high-speed traction. We now have to note that a speed of 130⅔ miles an hour has been attained since this paper last went to press, and even that may have been excelled before our comment gets into type. Just how long our German friends are going to keep this up we do not know, but it is safe to infer that they are still after that 150 miles an hour, which has been mentioned as their latest objective goal. At any rate, all that they have accomplished is vastly to their credit, even if they did not add another inch to their speed.

All this, moreover, is no idle *tour de force*. It has been supposed or suggested that the main idea was to get a method of transporting troops swiftly; but we ventured to intimate quietly some weeks ago that a new commercial road from Berlin to Hamburg might be found awaiting creation for high-speed purposes, after some of these problems had been solved. Confirmation of such a forecast is found in a cable dispatch this week from Germany stating that an electric road is to be equipped between Hamburg and Berlin, to operate at 100 miles an hour, and that the Emperor himself is deeply interested in the execution of the project. It is said, also, that this may be the first in a network of such roads covering the empire. We take the distance between Hamburg and Berlin to be somewhat over 150 miles, and this will be made in one and a-half hours on the new schedule. The carrying out of such a plan will be watched with deep interest in America, for we, with our vast stretches separating big centers of population, trying to get into closer touch all the time, have a great stake in the success of enterprises of this character. As to the suggested "network" of such roads, that is undoubtedly a very "large order" for the present stage of development. Many questions have still to be studied, not the least of which are the signaling on the technical side, and the profitable schedule on the commercial side. But there is some consolation in knowing that the limit of speed in transportation has been advanced and that humanity is not restricted forever to the jog-trot of the present steam régime with an average far below 50 miles an hour.

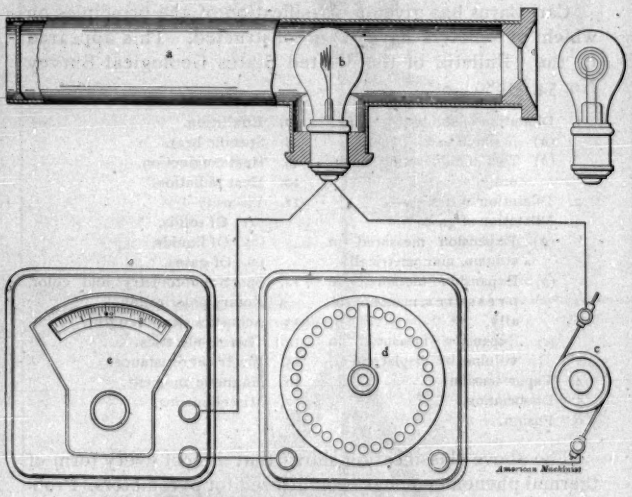
The Morse Heat Gauge.

[*Being the Report of the Committee on Science and the Arts on the invention of Everett F. Morse.*

Sub-Committee: G. H. Clamer, Chairman, James Christie, John M. Hartman, W. D. Harris.]

[No. 2240.]

The Franklin Institute, acting through its Committee on Science and the Arts, investigating the merits of the heat



Diagrammatic representation of Heat Gauge.

gauge, invented by Everett F. Morse, of Trumansburg, N. Y., reports as follows:

Pyrometry is the term applied to measurement of high temperature such as cannot be determined by the ordinary thermometer. There have been many methods proposed for the measurement of such elevated temperatures, and a number of quite satisfactory instruments designed. The

importance of pyrometric determinations is daily increasing, and the field of usefulness of a good heat gauge is an extensive one indeed.

Pyrometers have been made which depend on the method of mixtures, otherwise known as calorimeters, the principle of which is too well known to need description. Some have depended on the expansion of metallic strips or rods, and Messrs. Valy and Schorley employed a fluid alloy of sodium and potassium with mercury in a hard-glass tube by which means a temperature up to 600° C. could be read, as on an ordinary thermometer.

Carl Barus has given a classification of the principles on which pyrometers have been constructed. This appeared in the "Bulletin of the United States Geological Survey No. 54," 1889:

1. Dilatation of solids—
   (*a*) A single solid.
   (*b*) Two solids acting differentially.
2. Dilatation of liquids—
3. Dilatation of gases—
   (*a*) Expansion measured in volume, manometrically.
   (*b*) Expansion measured in pressures, manometrically.
   (*c*) Expansion measured in volume by displacement.
4. Vapor tension.
5. Dissociation.
6. Fusion.
7. Ebullition.
8. Specific heat.
9. Heat conduction.
10. Heat radiation.
11. Viscosity—
    (*a*) Of solids.
    (*b*) Of liquids.
    (*c*) Of gases.
12. Spectrophotometry and color. Rotary polarization.
13. Acoustics (wave length).
14. Thermo-electrics.
15. Electrical resistance.
16. Magnetic moment.
17. Miscellaneous.

The above classification shows that almost every form of thermal phenomenon has been utilized for pyrometers. Probably the most important in practical application, because of its simplicity, is the method of fusion, viz., by means of various metals which, when brought into a heated atmosphere, or in the vicinity of a heated body, will melt, the melting point being known; thus a temperature which will melt one alloy and not another can be said to lie between the two. This, of course, gives but approximate results inside of a wide range, and hence is limited in its usefulness.

Heat Gauge as used with a blacksmith's fire.

The most important application of this method has been in the determination of temperature of hot blasts in connection with blast-furnace practice.

Quite a satisfactory pyrometer is built on the principle that if a current of water of known temperature be allowed to run through a coiled tube, the temperature of the out-flowing water will be proportionate to the temperature through which it has passed.

An important advance was made with pyrometric construction when Sir Wm. Siemens discovered that an instrument could be made to gauge temperatures quite accurately, by comparing the resistance of platinum wire at ordinary temperatures with the same at an elevated degree. The method used being to pass a current through a platinum wire around about a porcelain tube, balancing the resistance by means of another coil, so that equal currents would pass through both. The platinum wire when placed in the heated medium is increased in resistance—the smaller current traversing it. This current, compared with that passing through the standard coil, is reduced to temperatures recorded on a table. Other instruments have been produced which depend upon the electrical resistance of bodies at elevated temperatures, notably the one of Professor LeChatelier, which consists of a thermo-couple composed of platinum and an alloy of platinum with 10 per cent. rhodium. Such a couple, under the effects of heat, is capable of generating a current which can be measured on a sensitive galvanometer. The galvanometer in practice is standardized for direct reading of temperature. This pyrometer is very extensively used at the present time, and your chairman has had some experience with this apparatus in the measurement of the temperature of molten metals. This instrument is very trustworthy for the measurement of furnace chambers, etc.; but, owing to the thick walls of clay, or infusible material, with which it is necessary to protect a thermo-couple, takes a long while to produce a variation. A further difficulty lies in the inability to produce a clay protection which is substantial enough to make the instrument successful in the hands of any but a careful operator, and is entirely too deli-

Heat Gauge as used with a heating furnace.

Heat Gauge as used with a lead bath.

cate a contrivance for every-day use in the foundry. It was on this account that its use was abandoned.

Other pyrometers have been produced, of which the Morse gauge is a type, known as "optical pyrometers." In this, the eye of the workman, supplemented by an instrument which enables him to record the intensity of the radiations, becomes a pyrometer, so that the old method of judging temperatures by the appearance of the same is rendered comparatively accurate, and familiar indications of bright redness, etc., are subjected to direct measurements.

The optical pyrometer of LeChatelier is a photometric instrument. In this apparatus the rays emitted from a standard are compared with the rays emitted from a heated body whose temperature is to be determined. A red glass is interposed in the eye-piece and only red rays enter the eye. The photometer depends upon the adjustment to the same brightness of two images, one of the standard and the other of the compared body. The adjustment is made by means of two diaphragms having V-shaped notches opposite one another. They are operated by means of a milled head, and the light admitted depends upon their respective distance from one another. The measurement of this distance com pared with the distance apart when observing the standard light is reduced to temperature.

Other optical instruments have been put upon the market, but the one under consideration is perhaps the most ingenious invention, because of its simplicity.

The invention of Everett F. Morse is covered by two patents, granted April 1, 1902, the first covering the process, and the second the method of gauging the temperature by heated substances. First, No. 696,619, and the second, No. 696,878.

The methods of optical pyrometry employed previous to the invention of Mr. Morse are unreliable, chiefly because the optical standards for comparsion have been placed to one side of the compared, and consequently such comparisons are greatly dependent upon the personal equation of the observer.

The gist of Mr. Morse's invention is best stated in the

first patent, viz.: The method of gauging the temperature of a material which becomes incandescent when heated, consists in comparing said material, heated to luminous state, with an optical standard so that at least a portion of one is in the path of the rays passing from the other to the eye observing the standard and material and noting when the one immerges in the other to such a degree as to indicate the correct temperature within the necessary limits.

The apparatus of Mr. Morse consists first of a standard and by preference he has chosen the simple incandescent lamp, the temperature or color of which can be regulated by resistance, and the amount of current passing through the circuit recorded on a mill-ampere meter. This makes a very convenient and reliable standard. The lamp is enclosed in a tube which may or may not be open at both ends as desired. The tube containing the standard is held in such a position that the rays passing through the object of comparison will be superposed by the rays from the glowing lamp, the color intensity of which is regulated by means of the resistance in the circuit, that it will be of the same intensity, and will apparently be obliterated from view. At this point an observation of the ammeter and a comparison with the table, the result of calibration by means of a LeChatelier pyrometer, gives the ampere reading direct in temperatures.

The Morse Gauge is an exceedingly simple and practical device founded on good scientific principles, and should have a wide field of usefulness, especially in the study of that important question, the heat treatment of steel. It has been used by a number of prominent manufacturers for some time, whose testimonials form a part of the Committee's records.

In view of the novelty of the invention and its practical advantages over other apparatus and methods, the Institute recommends the award of the John Scott Legacy Premium and Medal to Everett F. Morse.

Adopted at the stated meeting of the Committee on Science and the Arts, June 10, 1902.

Attest: WM. H. WAHL, *Secretary.*

WASTE OF NATURAL GAS.

The reckless waste of the natural gas supplies of Pennsylvania, Ohio and Indiana is one of the greatest economic crimes committed in this country. Millions upon millions of feet of this ideal fuel were not utilized at all, and other millions of feet were burnt in huge flambeaux to advertise town sites.—*Engineering and Mining Journal.*

VANADIUM STEEL.

Metallurgic circles, especially abroad, have been interested recently in the singular properties of vanadium steel.

It appears that when from 3 to 5 parts per 1,000 of this metal, which is as yet very little known, are added to steel, it communicates remarkable properties.

Properly speaking, vanadium does not bestow on iron or steel any new property, but it doubles the coefficients of resistance to fracture under all circumstances (shock, crushing, elongation, etc.), and at the same time imparts such extreme hardness as to render it possible to reduce almost by half the thickness of the armor for vessels.

It is difficult to comprehend that the presence of from ⅓ to ½ per cent. of any element whatever in an iron alloy can have so intense and general an effect, though this effect is perhaps explained by the extreme avidity which under certain circumstances vanadium has for oxygen. This avidity might account for the fact that the presence of even the slightest quantities of vanadium in a bath of steel in fusion would lead to the immediate and absolute reduction of every trace of iron oxide still existing in the mass; now to these traces of oxide, which are inevitable without vanadium, the rupture of the best prepared steels is attributed. Crystals, even microscopic, of oxides would act like the stroke of a diamond on the thickest glass.

A peculiar property of vanadium steels is that they acquire their maximum of hardness, not by tempering, but by annealing at from 700° to 800° C. This has various consequences; for instance, a planing machine whose cutter is of vanadium steel is set at work with the greatest velocity and power. Soon the implement becomes heated, and even when it attains red heat, it still continues to take off shavings of iron or castings without exhibiting any exhaustion. It is almost unnecessary to remark that in such a case a cutter of ordinary steel would become completely softened and lose its cutting power.

This property is of particular importance for projectiles. It is known that the shock which they experience on striking the target raises them to an elevated temperature. If, by means of vanadium, this temperature does not diminish the hardness of their points, and consequently all their sharpness, is preserved, the penetrating force will remain intact.

The applications of vanadium may be numerous. It is said that they may cause a revolution in armaments. Incidentally, they would allow the construction of helmets and breast-plates, light and efficacious.

Vanadium has been valued as high as 130,000 francs per kilogram. It is now, we think, worth about 150 francs.—*L'Echo des Mines et de la Metallurgie.*

CHEMICAL SECTION.

Stated Meeting, held Thursday, November 5, 1903.

Fermentation without Yeast Cells: A Résumé of Buchner's Work.*

By Robert H. Bradbury.

I. HISTORICAL.

When fruit-juices or sugar-solutions are exposed to the air, the phenomena of fermentation gradually appear. A gas is evolved, the clear solution becomes turbid and a precipitate called yeast makes its appearance. At the same time, the liquid loses its sweet taste and acquires an alcoholic flavor and intoxicating properties. These observations are very ancient; fermented drinks have been prepared since the earliest times; but it is only since Lavoisier that it has been known that the chemical change is chiefly the separation of sugar into carbon dioxide and alcohol.

The rôle of the yeast long remained obscure. It was known that fruit-juices could be preserved if boiled and sealed up still hot; but this was ascribed to the absence of oxygen in the vessel. Leuwenhoek had ascertained in 1680 with the microscope the spherical or ellipsoidal shape of the individual constituents of yeast; but, instead of considering this a proof of organized structure, had regarded the substance as merely an albuminous precipitate, and compared the cells to starch granules. But in 1835–37 Cagniard de Latour and Theodor Schwann almost simultaneously made an important advance. The growth of the yeast was studied and its status as a living plant placed beyond doubt. It was shown that fruit-juices could be pre-

*Buchner has recently published a connected account of his researches (Die Zymasegärung, 1903). Those who wish to familiarize themselves with the revolutionary change which has been brought about in our views of fermentation, will find this book authoritative, fascinating and complete. It has been very freely used in the preparation of the present paper.

served by the boiling process even when there was a large supply of oxygen in the sealed vessel. Fermentation does not occur even when air is allowed access to the boiled juice, provided that the air has previously passed through a red-hot tube, or bubbled through strong sulphuric acid. On the other hand, the admission of ordinary air immediately causes fermentation and organisms simultaneously appear in the liquid.

Upon this basis was erected the "*vitalistic theory of fermentation*," according to which the cause of the phenomena is the life-processes of the yeast plant. Schwann assigned to the sugar the rôle of nutriment and to the alcohol and carbon dioxide that of excretion-products. This view was bitterly opposed by the chemists of the period, Liebig at their head. It is not remarkable that just after Wöhler's synthesis had dethroned the "vital principle" in organic chemistry chemists should object to converting what had been regarded as a chemical process into a vital act. Berzelius had already (1828) suggested that the action of the yeast was catalytic, and Liebig developed this idea into his "decomposition theory." He regarded the yeast as a body engaged in active putrefaction in the presence of which sugar became infected with the same change, just as a rotten apple may contaminate a good one, or a little soured wine produce a rapid transformation of good wine to vinegar under favorable conditions. This ill-defined conception had no experimental evidence in its favor. Dead and decaying yeast might have been regarded from this point of view—hardly the living, growing plant. But Liebig's influence was so immense that the idea held its ground until routed by the decisive experiments of Louis Pasteur, who proved in the most complete way that no putrefaction of the yeast occurs during fermentation; that the process depends upon the life of the yeast-cells, not upon their death, and that fermentation can occur in the entire absence of decomposing albuminous materials. The function of air in exciting fermentation in sterilized liquids he cleared up by filtering air through collodion wool, dissolving in alcoholic ether and examining the residue with the microscope. It was found

V.1
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to consist of the same organisms which are present in fermenting liquids. The destruction of Liebig's theory was completed by the proof that substances engaged in active decomposition, like hydrogen peroxide or a warm solution of ammonium nitrite, did not arouse fermentation.

Thus the vitalistic theory remained in complete possession of the field. But the mere fact that fermentation had never been observed in the absence of organisms does not prove that it is due to the life-processes of the yeast plant. There is an alternative possibility—that the cell contains a substance which acts catalytically on the sugar and brings about the transformation. This is the *enzyme theory*, stated by Moritz Traube in 1858, and that Pasteur himself believed in its possibility is shown by the fact that he made repeated unsuccessful attempts to extract the active substance from the cells by grinding them in a mortar, by freezing and then thawing—the idea being that the cell-wall might thus be burst and allow the contents to escape, and by immersing them in strong saline solutions so as to force the contents through the cell-walls by osmosis.

II. ENZYMES IN GENERAL.

So far enzymes have been obtained only from plants and animals; it has not been possible to prepare them artificially. Most of them are to be regarded as albuminoids, but not all, for some seem to be very low in nitrogen or even to be free from it. They are produced directly from the living protoplasm, and many of them are similar to it in chemical character but not identical with it. They stand on the boundary between living and dead matter, but are not to be considered as living, for the characteristic signs of life, assimilation, reproduction and the organized structure, are lacking. Their extraordinary instability and chemical activity cannot be viewed as evidence of life, for there are substances like colloidal platinum and the diazo-compounds which share these peculiarities. The enzymes are soluble in water and the solution passes through a filter of biscuit-porcelain, by which all bacteria are stopped. A dissolved living organism is unthinkable. The chemical constitution of the enzymes

is extremely complex and they are probably all asymmetric in configuration. This is a natural assumption, since they are complex products of the organism and the different action of some enzymes on enantiomorphous sugars is only explicable on the ground of asymmetry in the enzyme itself.

The enzymes appear to take no part in the chemical changes which they bring about. They are found unaltered after the reaction and are able to produce a transformation which is quantitatively entirely disproportionate to the amount of the enzyme present. In this respect, as Berzelius recognized, their behavior is entirely analogous to that of other substances acting catalytically. Among inorganic catalyzers, especially the colloidal solutions of metals like platinum, show striking analogies with the enzymes. This is interesting because it shows that the chemical activity is very possibly connected with the huge surface-development of a substance held in colloidal solution. The solutions of the enzymes are also colloidal.

III. THE EXTRACTION OF THE CONTENTS OF THE YEAST-CELL.

The cell-wall of yeast is far too elastic to be ruptured by mere grinding in a mortar. But when yeast dried by compression is mixed with an equal weight of fine quartz-sand and one-third of its weight of infusorial earth and the mixture vigorously ground, the cell-walls are burst by the attrition of the quartz particles and their contents escape. At the same time, the mixture, which is at first a dry white powder, becomes moist, gray-brown and plastic. With 400 grams of the mixture this change takes place in less than five minutes. The mixture is then subjected to strong hydraulic pressure, and the cell-liquid escapes and is received in a vessel immersed in ice-water. The sand plays the chief rôle in bursting the cell; the object of the infusorial earth is to make the mixture less slimy, so that it supports pressure better and yields a clearer filtrate. Only a portion of the cells is opened in this operation. If anything like a complete extraction of the cell-contents is desired, the grinding must be repeated a number of times. In one experiment there were five repetitions of the grinding and compression,

and in all 700 cubic centimeters of cell-liquid were obtained. The last fraction showed strong fermenting action, and it was clear that the yeast was by no means exhausted.

The elasticity of the cell-wall explains the failure of Pasteur's attempt to extract the contents by freezing. When the liquid is frozen, the membrane is distended a little, but not burst, and upon thawing it remains intact. But if the yeast is *pulverized while frozen*, the cell is broken, and upon melting the contents escape. This is the explanation of the following experiment: When 500 grams of dry yeast are mixed with 500 grams of solid carbon dioxide and the mixture ground in a mortar, the mass, which is at first frozen to stony hardness, gradually becomes soft and semi liquid. Upon filtering with a pump, only 100 cubic centimeters of cell-liquid were obtained, but its fermenting power was energetic. This method has not been used much, owing to the expense, the small yield and the long grinding required.

IV. THE PROPERTIES OF THE CELL-LIQUID.

The liquid obtained by either of the preceding methods is yellow or brownish-yellow and almost clear. It smells and tastes strongly of yeast. The reaction is acid, and this is not due to to carbonic acid, for the acid reaction is not removed by evaporation to one-half volume in a vacuum. Addition of strong potassium hydroxide, of mineral acids, or of acetic acid, causes such a copious coagulation of albumin that the whole mass often becomes solid. The same thing happens when the liquid is boiled. If it is only warmed gently (50°), the coagulation is slight, but the fermenting power disappears. Upon preservation, the fermenting power of the liquid is soon lost, and then, when it is boiled, the coagulation is much diminished, or does not take place at all. This loss of activity is rapid at ordinary temperatures, but even in a refrigerator it is very noticeable in one day, and complete in two or three.

V. ACELLULAR FERMENTATION.

When sugar is dissolved in the liquid, or a strong sugar-solution added to it, the phenomena of fermentation mani-

fest themselves almost at once—so rapidly that is possible to show the process as a lecture-experiment. Thus in one experiment in which 100 cubic centimeters of cell-liquid were mixed with sugar; 6 cubic centimeters of gas were evolved in the first fifteen minutes; in another similar experiment, 6·5 cubic centimeters of gas in the same time. This gas is pure carbon dioxide, for it renders lime-water turbid, and when collected over mercury is completely absorbed, if a little solution of caustic potash is admitted to the tube. The process has been followed quantitatively, and it has been shown that carbon dioxide and alcohol are produced in approximately equal quantities. It will be remembered that this is also the case in ordinary yeast-fermentation as shown by the familiar equation, due to Gay Lussac:

$$C_6H_{12}O_6 = 2C_2H_6O + 2CO_2$$

In this respect, and in the considerable development of heat which occurs, acellular fermentation is similar to ordinary fermentation. But there are some important differences. Thus, the cell-liquid obtained by the methods just discussed, slowly ferments glycogen, dextrin and even starch, which is not the case with living yeast-cells. Again, yeast-cells act upon glucose more rapidly than upon fructose, so that a fermenting solution of invert-sugar gradually becomes more and more lævo-rotatory. But the cell-liquid ferments glucose and fructose with exactly the same speed, so that the volume of CO_2, liberated in the two cases, is exactly the same after the same lapse of time. Of course, the same volume of cell-liquid was taken in the two experiments, and the same weight of glucose in one as of fructose in the other. The most probable explanation of this interesting fact is that glucose and fructose differ in the speed with which they diffuse through the cell-wall, and when the membrane is removed and the liquid acts directly upon the sugar the difference disappears.

It is well known that small quantities of glycerine and succinic acid are so constantly produced in ordinary fermentation that Pasteur regarded them as products of the process in the same sense as alcohol and carbon dioxide. Now

it is so difficult to estimate glycerine and succinic acid in such a mixture as the cell-liquid that Buchner does not regard his experiments as quite conclusive, but they indicate strongly that in the acellular fermentation these two substances are not produced at all. We shall have to regard them, therefore, as products of the nutrition of the cells, having no direct connection with the fermentation process.

VI. THE CAUSE OF FERMENTATION IN THE ABSENCE OF YEAST-CELLS.

The most important fact that emerges from the experimental results just stated is that the complex mechanism of the yeast-cell is not necessary for the fermentation process. The phenomena occur in its absence. But is this conclusion certain? Is it not possible that a sufficient number of cells have passed through the cloth of the hydraulic press and escaped the following filtration to account for the results? This objection seems serious, but it is easily met. The acellular fermentation is too rapid and energetic to be caused by the few hundreds of cells which could be present in the liquid. Millions would be necessary. More conclusive is the fact that the cell-liquid can be passed through a Berkefeldt filter and then through a Chamberland filter of biscuit porcelain without losing its fermenting power. This operation completely frees it from cells, as has been shown by bacteriological methods.

Driven from the conception that the yeast-cell is the active agent, the advocates of vitalistic views retired a little and took up a new position. True, fermentation occurs in the absence of the yeast-cell, but the protoplasm of the cell is still living. This escapes from the cell when the wall is broken and gets into the liquid. It is to the action of this living protoplasm upon the sugar that fermentation is due.

It is difficult to speak with proper moderation of an explanation which requires us to think of a "living liquid," soluble in water—of a "living" something which passes unchanged through filters impervious to all organisms—of a "living" substance which has no structure, no assimilation, and no reproduction. Anyone who advocates this view

should be required to explain exactly what he means by life, since it is clear that his conception of the term differs profoundly from that of normal men in general. We might as well regard the carbon dioxide of the lungs or the oxygen from plant-leaves as living.

This view may be dismissed as not possessing the definiteness which we have a right to demand of a scientific hypothesis. When, as in this case, a great step has been made in the separation of a complex phenomenon into its elements, the attempt to retain the old explanation by altering a definition is always futile and retrogressive. It may be worth while to mention a few facts which make the explanation—so far as it is capable of definite formulation—entirely inadmissible. Toluene in 1 per cent. solution entirely arrests the growth and fermenting action of yeast-cells, but does not interfere with acellular fermentation. We should have to assume, therefore, that after the removal of the cell-wall the naked living protoplasm becomes much less sensitive to the action of the toluene than it was before. The active agent in the cell liquid is precipitated as a white powder by adding a mixture of alcohol and ether. It can even be dissolved in water and the precipitation repeated without destroying the fermenting power. Yeast-cells are immediately killed by this treatment and it is impossible that living proloplasm should survive it.

When yeast-cells are killed by being soaked in acetone or in alcohol the vital functions of growth and assimilation cease, but the fermenting power remains, although the protoplasm is undoubtedly dead. In one experiment some of these *dead* cells were ground with quartz and infusorial earth and subjected to pressure just as previously described. The resulting liquid—which possessed a strong fermenting power—was precipitated by a mixture of alcohol and ether. The solid was dissolved in water to a clear light-brown liquid and again precipitated with alcohol and ether. The liquid produced by dissolving this final precipitate in water fermented sugar vigorously. A "living" liquid extracted from dead yeast-cells and passing still living through the treatment just described is simply unthinkable.

The experimental results, therefore, without any admixture of speculation amount to this: that the cell-liquid contains a substance which gives rise to that separation of the sugar-molecule which we call fermentation. This substance cannot be regarded as living, for it can be dissolved in water filtered through biscuit porcelain and precipitated again, dried and heated to over 100° without losing its activity. It is contained abundantly in dead yeast and can be extracted by exactly the same methods which apply to the living cells. In short, it behaves in exactly the same way as other unstable chemical compounds.

Now, the preceding paragraph—which contains nothing but pure fact from beginning to end—is simply a brief statement of the enzyme theory of fermentation. Moritz Traube's speculation has become a fact. Yeast contains an enzyme which is the active cause of alcoholic fermentation and the process must be classified with the other enzyme actions: it has been transferred from the domain of the biologist to that of the chemist.

VII. EXPERIMENTS DIRECTED TOWARD THE ISOLATION OF ZYMASE.

Buchner has given the name *zymase* to the enzyme of yeast, and has made many interesting experiments on its separation from the cell-liquid. That these attempts have not led to its preparation in pure condition is not surprising, for zymase, like all enzymes, is unstable, and the cell-liquid is a very complex mixture.

When the cell-liquid is simply frozen in a tall cylinder and then allowed to melt, it separates into two layers. The upper one is colorless, and consists mostly of water; the lower is red-brown, dense and ferments sugar much more intensely than the original liquid.

When the cell-liquid is allowed to fall into a mixture of alcohol and ether, a white precipitate is produced, which contains all the zymase. This is filtered at a pump and dried in a desiccator over sulphuric acid. It is a dry, white powder, which represents about 15 per cent. by weight of the original liquid. When 2 grams of it were mixed with

sugar and water in a long tube, the fermentation was so energetic that in fifteen minutes the mass frothed over at the top. The powder can be dissolved in water and the precipitation by alcohol-ether, repeated without injury to the enzyme, if the operation is rapidly performed. Long contact with alcohol reduces or destroys the fermenting power.

However, the powder prepared by the preceding method is not pure zymase, or anything like it. In fact, it can be shown that, in all probability, the zymase is only a very small fraction of its mass. When cell-liquid is dropped into a small quantity of alcoholic ether, the albumins are precipitated, but not the zymase, so that the precipitate has no fermenting power. On the other hand, when a large quantity of alcoholic ether is employed, the zymase also precipitates. But when equal volumes of the cell-liquis are employed in the two experiments, the weight of the two precipitates is almost exactly the same, though one contains all the zymase and the other apparently contains none of it.*

Instead of alcoholic ether, acetone can be employed in this method, but its use offers no special advantage. Wood alcohol entirely destroys the enzyme, for both precipitate and filtrate are without action on sugar.

When the cell-liquid is carefully evaporated to dryness at 35° under reduced pressure, a yellowish powder is obtained, which has a pleasant odor of yeast and is completely soluble in water. This possesses all the fermenting power of the original liquid, and retains it unchanged for a year or more. Eight hours heating at 85° did not affect the activity.

VIII. DEAD YEAST.

Yeast is dried as far as possible by pressure, and slowly introduced through a sieve into a large quantity of acetone in a flat dish. The yeast is allowed to remain in the liquid ten minutes. It is then filtered and subjected to a second acetone treatment. Finally, the acetone is removed by

* It may be pointed out *en passant* that this experiment constitutes another disagreeable difficulty for the advocates of living protoplasm. They are forced to assume that the protoplasm is killed by a small quantity of alcoholic ether, but resists perfectly the action of a large quantity.

washing with a little ether, and the product heated to 45° for a time to drive off the ether. The result is a dry, white powder. It contains no living cells, for it is incapable of growth or reproduction, as has been shown by convincing experiments. Its fermenting action is intense. A tube half filled with a liquid containing 2 grams of dead yeast and 1 gram of sugar foamed over forty minutes after the beginning of the experiment. Dead yeast retains its activity almost unchanged for six months or more. All these facts are inexplicable by the hypothesis of living protoplasm, but they are natural consequences of the enzyme explanation.

IX. CONSEQUENCES.

The great result of Buchner's work is that the yeast-cell is non-essential to the fermentation process. Its only function is to produce and store up the zymase. Fermentation itself is a purely chemical process. We are now in a position to answer the old question whether fermentation takes place inside or outside the yeast-cell. Since the zymase never passes through the unbroken cell-wall the inside of the cell is the theatre of the process. The sugar goes to meet the enzyme by diffusion through the membrane and when we consider the speed with which fermentation progresses it is clear that the cell-membrane must be the seat of osmotic phenomena of exceptional intensity.

Zymase is the first example of a new class of enzymes—those which never leave the cell during its life. These may be called endo-enzymes. Most enzymes, when secreted, leave the cell and exert their chemical activity in an outside liquid. It will be observed that the cell loses some of its importance in biology as a result of this work. It seems that for every specific chemical act of the cell there is a specific enzyme which can do the same thing in the cell's absence. When the process of dissection and explanation of the cellular activities is finished what will remain as actual vital performance?

The scientific importance of Buchner's discovery is immense, but there is no prospect of any direct practical application. The synthesis of zymase, while a possibility,

is a very remote one, and in the meantime it is far simpler to employ yeast than to extract the cell-liquid and use it for fermentation. For in yeast new zymase is constantly produced, while in the cell-liquid or the precipitates made from it, this is impossible. Indirectly the practical results of the discovery will be of vast value. It points the way, for instance, to researches on the production of zymase in the yeast-cell, and the ascertainment of the most favorable conditions for the production and storing up of the enzyme would produce a revolution in fermentation technique. The attainment of this information is now perfectly possible and work directed toward it has already begun.

CENTRAL MANUAL TRAINING SCHOOL,
PHILADELPHIA, November, 1903.

THE PRODUCTION OF QUICKSILVER IN 1902.

The production of quicksilver in the United States during 1902, says Dr. Joseph Struthers in his report to the United States Geological Survey, amounted to 34,451 flasks of 76½ pounds each, valued at $1,500,412, as compared with 29,727 flasks, valued at $1,382,305, in 1901, an increase in quantity of 4,724 flasks and in value of $118,107. California contributed the greater part of the output, amounting to 29,199 flasks, as compared with 26,720 flasks in 1901. Texas reported 5,252 flasks, as compared with 2,932 flasks in 1901, both States thus showing an increase in the production above that of the preceding year. Oregon, which furnished 75 flasks in 1901, reported no production during 1902, the quicksilver mining operations in that State being limited to development work.

The report contains a detailed review, by Mr. William Forstner, of the progress in quicksilver mining in California during 1902. As is well known, California has produced nearly the entire output of quicksilver in the United States, the quantity to be credited to that State since 1850 amounting to 1,913,258 flasks, of which the New Almaden mine, in Santa Clara County, has furnished more than 50 per cent.

The production of quicksilver in Texas during 1902, valued at $228,620, as compared with a value of $132.438 in 1901, shows a very active development of the industry. The entire output for both years was produced by the Marfa and Mariposa Mining Company, operating at Terlingua, Brewster County.

The exports of quicksilver for 1902 amounted to 13,247 flasks, valued at $575,099, as compared with 11,219 flasks, valued at $475,609, in 1901. Of the exports, 8,913 flasks, valued at $383,578, went out of the port of San Francisco, nearly one-half going to Hongkong.

Section of Photography and Microscopy.

Stated Meeting, held Thursday, October 29, 1903.

Upon Changing Photographic Plates from the Developing to the Fixing Bath Without Recourse to the Dark-Room.

By Arthur W. McCurdy.
(Communicated.)

(1) Let a photographic plate, which has been exposed in a camera, be developed in the dark-room in the usual way.

(2) After development place the plate under a tap of running water until the developer is thoroughly washed off.

(3) Open up the dark-room to daylight and place the plate in the fixing bath.

Fixation, without fog, will be complete in about ten or fifteen minutes, according to the strength of the bath used.

I was led to the above experiment by the fact that dealers are using developing machines in the dark-room to develop films because of the increased ease and speed by which films can be handled with the machine. Instead of putting the fixing bath into the machine, they withdraw the film after washing, place it in a tray containing a fixing bath prepared for a great number of films, and immediately proceed to develop a new film.

It at once occurred to me that it would be very important to devise a method of development by which the amateur, who has no dark-room, might be enabled to attain the speed of the dealer who has a dark-room.

The following experiments, (*a*), (*b*), (*c*), led up to (*d*), previously mentioned.

(*a*) Submit an exposed plate to the action of the developer, wash and fix in the dark-room and the result will be a negative free from fog.

(*b*) Plunge an exposed plate, without development, into the fixing bath in daylight. After fixation the plate will be clear.

(*c*) Submit an exposed plate to the action of the developer in the dark-room, and in daylight, before washing, plunge it into the fixing bath. The plate will be fogged.

(*d*) Submit an exposed plate to the action of the developer, and, after washing off the developer in the dark-room, plunge the plate into the fixing bath in daylight. The negative will be found free from fog. (See *ante*.)

The developing machine is admirably adapted for just such an experiment. An exposed cartridge can be placed in it in daylight, can be developed in daylight, can be washed in daylight; and in daylight the carrier, black paper and film can be unrolled, the film torn off from the paper and immersed in the fixing bath, prepared for a number of films, in another dish. In such an experiment I have found the negative to be free from fog. Thorough washing after development, and before exposure to the light, is the *sine qua non*. To obtain thorough washing after development, place the machine under a tap of running water, rotate the film and frequently pour off the water until it runs clear.* Washing should be complete in about two minutes, and the machine be ready for the immediate development of another film.

Thus a method is pointed out by which the amateur, without a dark-room, may attain the speed of the dealer with a dark-room.

DISCUSSION.

MR. U. C. WANNER:—The paper of Mr. Arthur W. McCurdy, of Toronto, Canada, on the above subject suggested the following experiments:

I exposed four Bradley's "Extra-Speed" plates twenty seconds each at U. S. stop 128 on a dull, cloudy morning in October, between 7.30 and 7.50 A.M., and a fifth plate two seconds at the same time and stop. The first of the four plates was developed as an over-exposed plate with pyrogallic acid developer, and fixed in the usual way, in the dark.

The second was developed precisely like the first and when development was completed, was thoroughly rinsed

* In this experiment I used pyrogallic acid developer.

under the tap and exposed to gaslight for half an hour and then fixed in light. It was necessary to mark the plates to know which was fixed in the dark and which in the light. The third plate developed was the two-second exposure, treating it for under-exposure, after securing all the detail possible and developing the high lights almost to a harshness. I rinsed the plate thoroughly and exposed to gaslight for half an hour, then redeveloped the plate in a solution one-half the strength of the original until the entire surface of the plate was veiled that little detail could be seen in examination of plate by the ruby lamp. The plate was again thoroughly rinsed and exposed to gaslight for a considerable time, after which it was fixed in light.

The veiling of the film produced a much better printing negative than would have been possible without it in a plate so much under-exposed, by giving a better printing density to the entire negative, and especially to the shadows, without affecting the detail to any appreciable extent. This, of course, must be done with considerable care and judgment, as carrying the veiling too far would be at the sacrifice of brilliancy and detail; and again, this might be of use in securing diffusion or indistinctness for art purposes.

The fourth and fifth to be developed were treated precisely as the first and second, and, when development was complete, washed under the tap for a period not exceeding two minutes, after which they were dried in daylight. The fourth was fixed after being exposed to daylight an entire day, and the fifth was fixed before the Section of Photography and Microscopy on October 29, 1903, after two days' exposure to daylight.

There is no apparent difference in the resulting negatives from the plates of same exposure and development, and the under-exposure was very materially improved by the heroic treatment given it.

These experiments fully bear out the claims made by Mr. McCurdy, and the conclusion is that a plate or film, washed free from the reducing agent used in developing the image, may be fixed as well in the light as in the dark, and at the convenience of the operator.

METALLIC CALCIUM BY ELECTROLYSIS.

A problem that up to the present has stubbornly resisted all attempts at its solution, to wit, the electrolytic production of metallic calcium from lime, has at last yielded to the onward march of science. The triumph was accomplished in the Electro-Metallurgic Institute at Aix-la-Chapelle, by Professor Borchers and one of his engineering students, Herr Stoekem. The process employed is similar to that of the production of aluminum from beauxite, as described in the *Zeitschrift für Elektrochemie*. Aluminum, as is generally known, is separated out of a molten mixture of cryolite and alumina, and the process is even simpler, since only one material is submitted to electrolysis, calcium chloride, to wit, which melts at about 800° C. (1,475° F.).

Certain peculiarities of calcium, not possessed by aluminum, make special care in arranging the electrodes necessary, and even then many failures are encountered. Without entering into a history of the process employed by the professor and his pupil, we would say that the possession of a method of producing metallic calcium at will, easily and cheaply, is of great importance to chemistry, in its application to the arts and manufactures. It is not, of course, available for manufacturing vessels, implements or tools, and it does not keep when exposed to the atmosphere, but is converted by it into calcium oxide, quicklime. It is, as remarked, in the chemical industries that calcium will find its greatest usefulness, and especially in organic chemistry, where the need for a cheap metal, with powerful reducing properties, stronger than those of aluminum, magnesium, and zinc, and weaker than metallic sodium and potassium, has for a long time been felt.

The cost of metallic calcium—about $22.50 per pound—has hitherto precluded its use in this capacity (*i. e.*, as a reducer), but, by the new process, this cost is lowered about 5,000 times, it being produced at the amazingly low rate of 45 cents per hundred weight—a fact whose importance to organic chemistry it is impossible to overestimate. Besides its importance in this direction, the discovery is of high interest to the iron industry. To free iron from phosphorus, sulphur and oxygen, an addition of aluminum to the molten ore has hitherto been necessary, and while a specimen of iron containing aluminum is better than one containing phosphorus, or sulphur or oxygen, it is not as good as absolutely pure iron as regards resistance to strain and fracture. Should the theory now maintained by experts that the amount of calcium necessary to reduce these deleterious contents be so small as to virtually leave the iron in a state of purity—should this be confirmed in actnal practice, and should it be found that the calcium plays no deleterious part, the new industry of calcium producing has a most brilliant future. The same may be said for metallic strontium, which is now being produced cheaply and plentifully.—*Nat. Drug.*

V.
19

ELECTRICAL SECTION.

Stated Meeting held Thursday, October 8, 1903.

Rail Bonds.

By W. E. Harrington.
General Manager Camden and Suburban Railway Company.

Rail-bonding is a subject that is usually regarded as simple, and therefore not requiring much detail attention by railway companies and engineers; to an extent this is true. The writer only proposes to treat the subject in a way to bring attention to the salient features, bonds and methods employed recently, testing, and to draw conclusions based largely upon experience.

The literature upon the subject of rail-bonding is not very extensive. Our available data and knowledge have been derived chiefly from the pen of manufacturers or inventors who have been financially interested in the bonds about which they have written.

The subject, however, is an exceedingly interesting one, and if railway companies and engineers who have to do with bonding would make a record of their observations and experiences great benefit generally would unquestionably be derived.

The form or design and cost of bond is of secondary importance, the two vital features always to be considered are,

A—Life
B—Conductivity } Primary.

C—Cost
D—Design } Secondary.

The life of a bond, and its value after a period of active use, must always be regarded as the most important item in making a determination as to the adoption of a bond. This can only be found either by experience of the user, or by consulting with others who have had experience. The value of the bond should not be lost sight of after it has served out its usefulness.

The conductivity of a bond is a quality that can so read-

ily be determined that no railway or engineer should adopt any form of bond until tests have been made and data established in reference thereto. It is manifestly unwise to adopt in the outset a bond whose conductivity makes the resistance around the rail joint higher than the corresponding length of solid rail section. Furthermore, tests should be made to determine the ratio of conductivity of joint to solid rail after the bond considered has been in actual service and use, for as long a period from which data can be obtained.

The cost of bonding represents so small a percentage of the total cost of the construction of a railway that this item need only be treated similarly to all other business propositions; for instance, if a railway from its knowledge of its service knows that a 100-pound T-rail is required, it proceeds to obtain the 100-pound rails on the most favorable terms possible, without any consideration of 50- or 60-pound rails.

The design of a bond is immaterial, providing positive knowledge is had as to its life and conductivity.

Poor bonding results in seriously affecting the proper and satisfactory operation of an electric railway. The following is a list of troubles incident to poor or incomplete bonding, the correction of any one of which, alone, would pay on any railway the entire cost of proper bonding:

A—Watt loss.

B—Depreciation of car electrical equipment.

C—Car service—loss in schedules.

D—Electrolysis.

The necessity of providing for the return of currents to power station by ample conductors and good bonded contacts goes without question.

Types of bonds now upon the market are generally in use, and methods of application are shown herewith and represent the best practice in the United States.

PROTECTED RAIL-BONDS.

The bonds are made of flat, parallel laid copper wires, formed into loops from one continuous strand. Pure

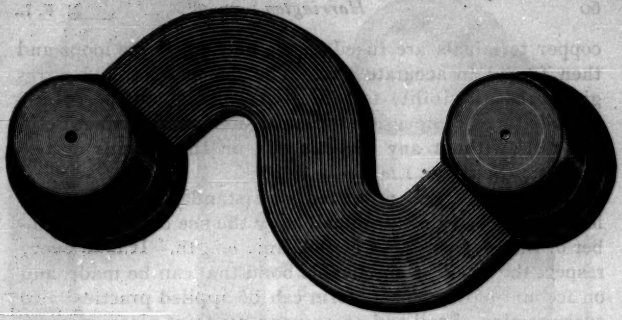

FIG. 1.—Type "C 3" protected bond (improved "S" bond), made extra flexible by the use of a large number of thin flat wires, all wires being of the same length. Maximum thickness, ¼ inch. Total depth, 2 inches.

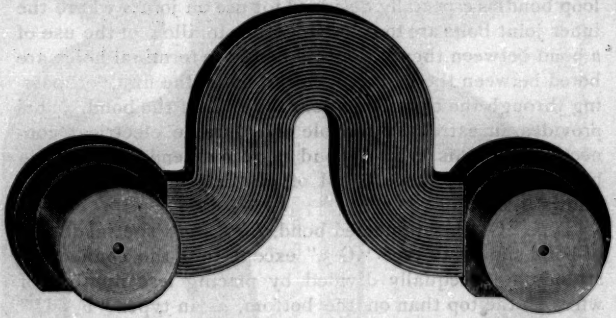

FIG. 2.—Type "B 3" protected bond (improved horseshoe bond), made extra flexible by the use of a large number of thin flat wires, all wires being of the same length. Maximum thickness, ¼ inch. Total depth, 2 inches.

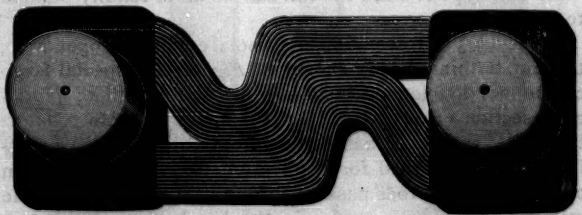

FIG. 3.—Type "E 3." Maximum thickness, ¼-inch. Total depth, 1¼ inches.

copper terminals are fused on the ends of these loops and then forged to accurate size. The flat parallel-laid wires give great flexibility to vibration and the shape of the various types compensate for expansion and contraction of the rails without any direct strain on the strands or terminals. (See *Figs. 1 to 9.*)

Type "E 3," *Fig. 3*, protected bond (standard closed double-loop bond) is made extra flexible by the use of a large number of thin flat wires, all of the same length. It is in every respect the smallest practicable bond that can be made, and on account of its compact form can be applied practically to every section of rail and accompanying joint-plates now on the market. It is recommended for use in paved work only.

Type "F 3," *Fig. 4*, protected bond (improved open double-loop bond) is especially designed for use on joints where the inner joint bolts are too close together to allow of the use of a bond between them. For this bond the terminal holes are bored between the first and second bolts, the first bolt passing through the open loops near the ends of the bond. This provides an extremely flexible and durable electrical connection, and this type of bond is recommended for single bonding in preference to all others in joints where space allows it.

Type "G 3 U" protected bond, *Fig. 5*, is a special design of bond similar to type "G 3," except that the connecting strands are unequally divided by placing less number of wires on the top than on the bottom, as in types "F 3 U" and "H 3 U." It is used in double bonding joints where there is much less space above the joint bolts than below. With this type of bond the rail can be more readily bonded to full capacity.

Type "J 3" protected bond (special compound open-loop, tandem terminal bond), shown in *Fig. 6*, is a special large compound, double-loop bond having four terminals, and a cross-section of 425,000 C.M. It is made up of forty-eight thin, flat wires and has a maximum thickness of only $\frac{1}{4}$ inch. It is designed for application to girder rail laid in concrete with tie rods passing through at the joining of the rails. The middle aperture in the bond allows for the tie

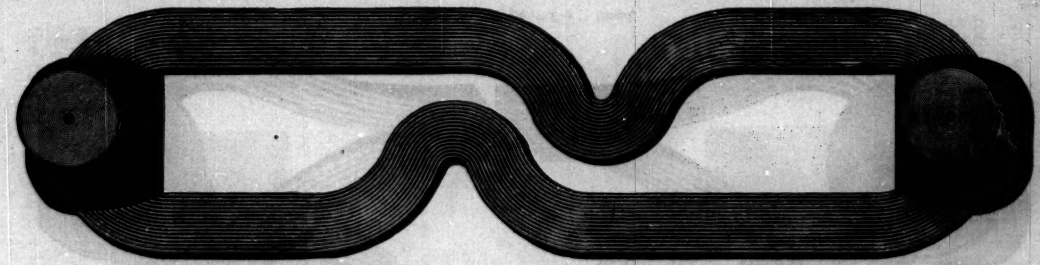

FIG. 4.—Type "F 3" protected bond. Maximum thickness, ¼-inch.
Total depth for ¼-inch bolt 1 ⅝ inches. Total depth for 1-inch bolts 1 ⅞ inches.

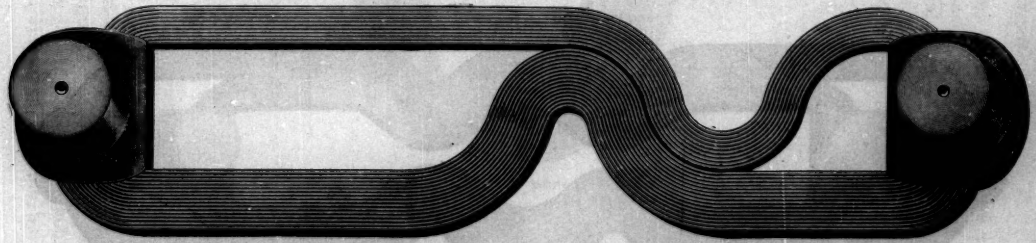

FIG. 5.—Type "G 3 U" protected bond.
Maximum thickness, ¼ inch. Total depth, according to the joint and capacity of bond.

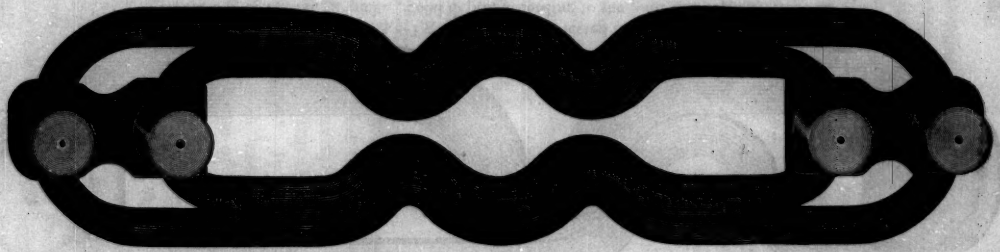

FIG. 6.—Type "J 3" protected bond.

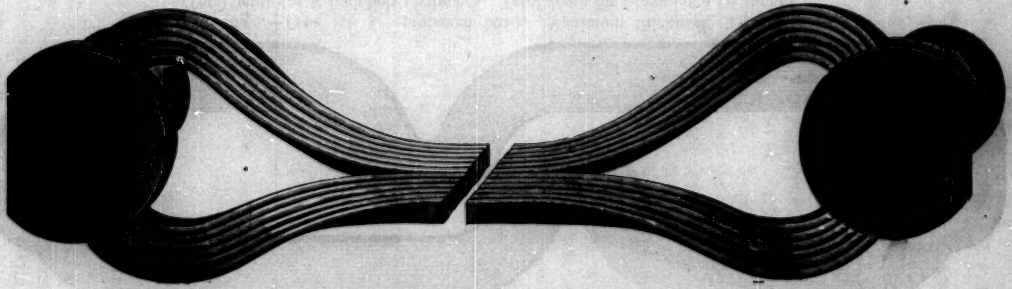

FIG. 8.—Type "P 4" bond.

rod and the apertures near the ends allow for the inner bolts. For this condition of space, tie rods and bolts, it is claimed that no bond of equal cross-section can be constructed, placed under the joint and proven practicable, except on the lines of the above protected bonds.

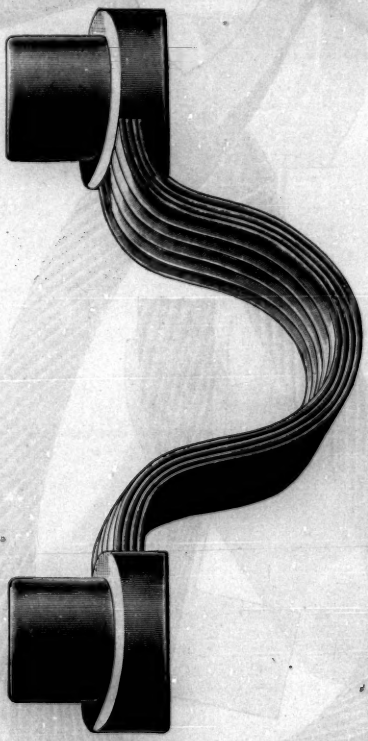

FIG. 7.—Type "L 1" protected bond.

Type "L 1" protected bond (standard "hydraulic" foot bond), *Fig. 7*, is especially designed to be applied to the foot of either T or girder rails. A tapered hole is punched in the foot of the rail, the large diameter of the hole being at

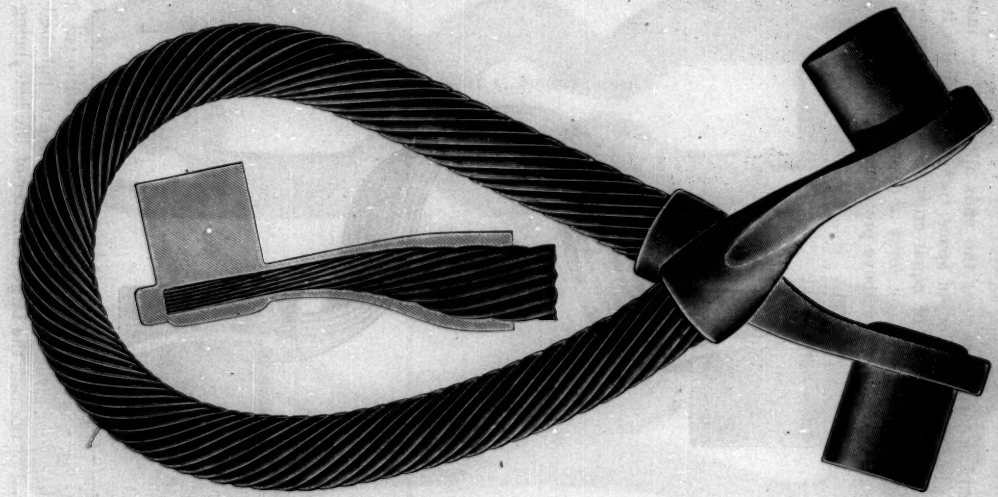

FIG. 9.—Type "P 4" bond.

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the top surface. The bond is applied underneath the foot, the hydraulic compressor forcing the terminal back into the tapered hole toward the small aperture until the end of

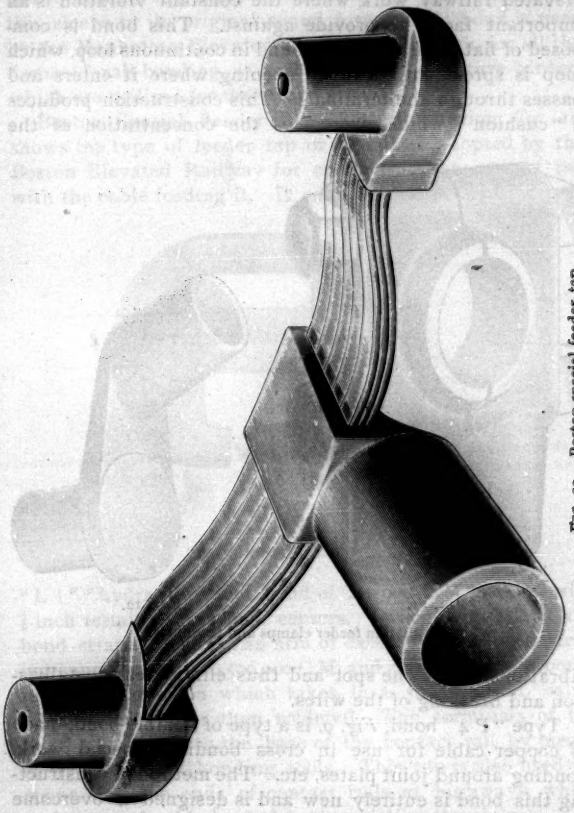

FIG. 10.—Boston special feeder tap.

terminal is flush with the top surface of rail foot. The terminal heads are tapered to compensate for the taper of rail foot and the uniform distribution of metal in the hole.

High speed "third rail" electric roads are using this bond on the contact rail.

Type "N 1" protected bond, *Fig. 8*, is designed for use on elevated railway work where the constant vibration is an important factor to provide against. This bond is composed of flat parallel wires, wound in continuous loop, which loop is spread into a broad opening where it enters and passes through the terminals. This construction produces a "cushion" which overcomes the concentration of the

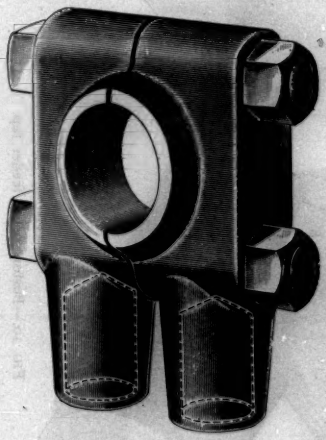

FIG. 11.

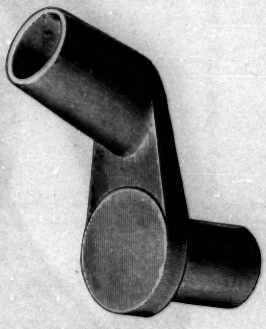

FIG. 12.

Manhattan feeder clamps and terminals.

vibrations in any one spot and thus eliminates crystallization and breaking of the wires.

Type "P 4" bond, *Fig. 9*, is a type of flexible bond, made of copper cable for use in cross bonding, special work, bonding around joint plates, etc. The method of constructing this bond is entirely new and is designed to overcome hammering and injuring the fine wires where they lead out of the terminal heads. The terminals are fused on to the cable in a long cylindrical neck, which is a part of the

terminal head. About one-half of this cylindrical neck, including the head, is then forged as shown by illustration, and the other half is left cylindrical, forming a protecting sleeve around the cable which leads out from the end of this sleeve in its original round form. This bond is used by the Manhattan Elevated Railway, New York, for all the "wheel" rail-bonding, as well as for the structure girders which are utilized for the return circuit.

Boston Special Feeder Tap. The illustration, *Fig. 10*, shows the type of feeder tap or equalizer adopted by the Boston Elevated Railway for connecting the contact rail with the cable feeding it. It consists practically of a type

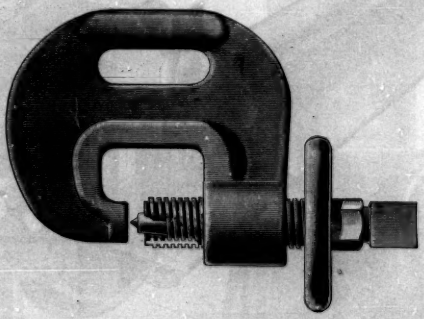

FIG. 13.—Rail-bond compressor.

"L 1" "hydraulic" foot bond of 250,000 C.M. section with $\frac{1}{8}$-inch terminals on 7-inch centers. Over the middle of the bond strands is fused an arm or extension, having a carrying capacity equal to 500,000 C.M. and over. A hole is bored into this extension which takes in a 500,000 C.M. cable. This connection is then soldered. The terminals of the bond are applied to the base of the contact rail by means of hydraulic foot bonding tools. This tap is also used for connecting the ends of contact rails at highways, where underground cable is used for completing the circuit.

Manhattan Feeder Clamps and Terminals. Illustrations, *Figs. 11—12*, show the types of clamps and terminals used by

the Manhattan Railway of New York for equalizing or tieing together the contact rail and the cable feeding it. The terminals have $\frac{7}{8}$ inch studs and are compressed in the web of rail. The sleeve is bored for 250,000 C.M. cable. The clamp is made in two halves and bolted together around the main feeder cable and then soldered thereto. The lower end of each half is bored for 250,000 C.M. cable, and short lengths of this cable connect the clamp and the termi-

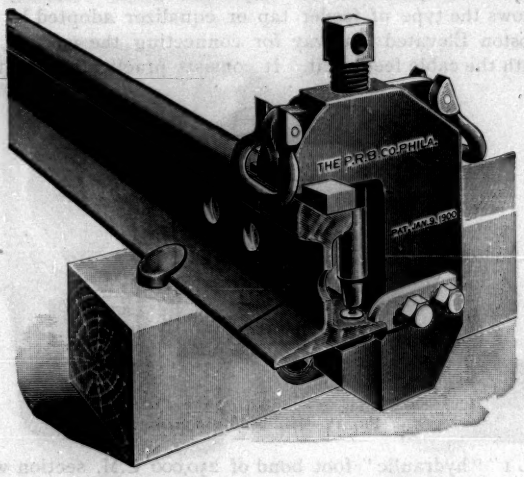

FIG. 14.—Type "4" foot-bond screw compressor.

nals by being soldered into the respective sleeves. The clamp is made to fit around a cable of 1,500,000 C.M.

Improved Rail-Bond Compressor.—After the bond terminals are slipped into the holes and the compressor, *Fig. 13*, placed in position, the outer screw is drawn up with the hand-wheel until it reaches the rail-web, thus holding the tool rigidly and drawing the bond "home." The inner screw is then drawn in with the wrench to compress the terminal, the point on the screw striking the indenture in the termi-

nal as a center guide. The compressing power of these machines is 20 tons.

Type "4" Foot-Bond Screw Compressor. This tool, *Fig. 14*, is designed for use in the application of type "L" protected foot-bonds to the base of rail. It is made with the body or frame of forged steel. The compressing screw is

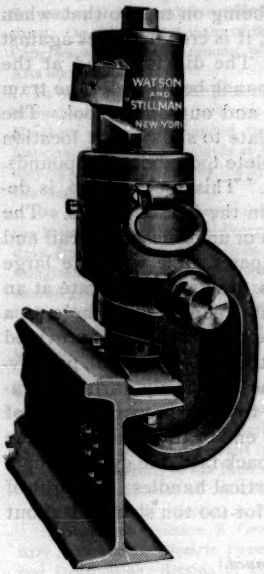

FIG. 15.
Hydraulic tram bond punch.

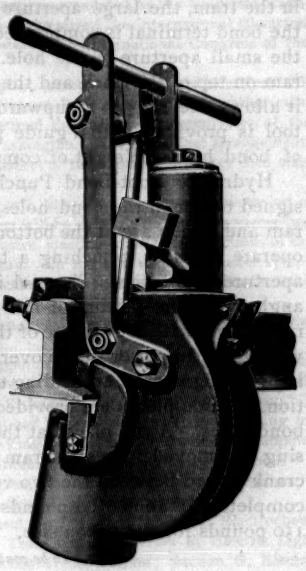

FIG. 16.
Hydraulic foot-bond punch.

made of tool steel with square cut threads and carefully tempered. Handles are provided for the convenient handling of the tool. The tightening wedge is attached to the body with a chain so as not to become lost or mislaid. Weight of tool, 65 pounds.

This type of compressor is for use when the bond holes are drilled at a right angle with the bottom surface of rail-

foot. The bonds in such instances are made with plain flat heads.

Hydraulic Tram Bond Punch. This tool, *Fig. 15*, is designed for punching the bond holes in the tram of girder-rails, principally for re-bonding in paved streets. It is necessary to remove but two belgian blocks, where such are used, to make room for the tool. A tapered hole is punched in the tram, the large aperture being on top, so that when the bond terminal is compressed, it is crowded back against the small aperture of the hole. The die is placed at the ram on top of the tram, and the punch being under the tram it allows the slug to fly upward and out of the tool. The tool is provided with a guide plate to show exact location of bond hole. Weight of complete tool about 140 pounds.

Hydraulic Foot-Bond Punch. This tool, *Fig. 16*, is designed to punch the bond holes in the foot of T-rails. The ram and punch are at the bottom or underneath the rail and operate upwards, punching a tapered hole with the large aperture at the top. The tool is designed to operate at an angle from the bottom of rail and punches the hole at a right angle with top surface of the rail base. Dogs provided with adjusting screws drop over the ball of the rail, preserving the alignment and holding the tool firmly during operation. Guide pieces are provided to show proper location of bond holes. A rod placed at the end of the punch after the slug is removed forces the ram back into the cylinder by a crank placed between the two vertical handles. Weight of complete tool about 180 pounds for 100 ton size and about 150 pounds for the 75-ton size.

(*To be continued.*)

Notes and Comments.

INTERNATIONAL ELECTRICAL CONGRESS AT ST. LOUIS, SEPTEMBER 12–17, 1904.—PRELIMINARY PROGRAM.

In connection with the Universal Exposition of St. Louis, in 1904, commemorating the Louisiana Purchase by the United States, it is proposed to hold an International Electrical Congress.

The last International Electrical Congress was held in 1900, in conjunction

with the Universal Exposition at Paris. The last preceding International Electrical Congress in the United States was held in 1893, in connection with the World's Fair at Chicago. Electrical Congresses held in the past have had an important influence on the world's progress in the knowledge of electricity and magnetism, and in the application of these sciences. It is confidently expected that the International Exposition of 1904, at St. Louis, may be equally successful in these directions.

The date set for the International Electrical Congress of St. Louis, is the week 12th to 17th September, 1904 (inclusive). This is the week preceding the session of the great Scientific Congress appointed by the Universal Exposition. On this account many of those who attend the International Electrical Congress will probably remain to attend the International Congress of the Arts and Sciences.

In accordance with the present plan, members arriving via New York will be enabled to reach St. Louis via Niagara Falls on Sunday, September 11th. Members will also be invited to attend the dedication ceremonies of the National Bureau of Standards at Washington. It is hoped that arrangements may be completed whereby the President of the United States may then meet the members.

On the morning of September 12th, at 11 A M., a general convocation of the International Electrical Congress will be called. On the four succeeding days, from the 13th to the 16th inclusive, meetings of the eight sections of the Congress will be held simultaneously. On the final day, September 17th, a second general convocation will be called. Members returning from St. Louis to New York may elect to stop off at Chicago and at Niagara Falls.

As at present proposed, the International Electrical Congress will comprise three distinct features :

(1) A Chamber of Delegates appointed by the various Governments, and essentially similar to the Chambers of Government Delegates at the International Electrical Congresses of Chicago in 1893, and of Paris in 1900. It would seem that sufficient material had been collected since 1900, calling for international action, to warrant inviting the various Governments to appoint delegates, as before, to the International Electrical Congress of St. Louis.

(2) The main body of the Congress, divided into the following sections :

General Theory : Section A, Mathematical, Experimental.

Applications : Section B, General Applications ; Section C, Electrochemistry ; Section D, Electric Power Transmission ; Section E, Electric Light and Distribution ; Section F, Electric Transportation ; Section G, Electric Communication ; Section H, Electrotherapeutics.

It is proposed to invite prominent men in various parts of the world to contribute special papers on subjects represented in the various sections and their subdivisions.

(3) Conventions simultaneously held, in connection with the Congress, by various electrical organizations in the United States. It is proposed that each section of the Congress may be able to hold its meeting under some plan of conjunction with the organization or organizations devoted to the progress of the work selected by that section. Steps have already been taken to enlist the sympathy of the various organizations, with a view to perfecting the details of co-operation at a later date.

The Universal Exposition at St. Louis has signified its intention of affording ample facilities for the accommodation of the Congress in its halls on the grounds of the Exposition.

The Committee of Organization of the Congress is as follows:

President, Elihu Thompson; Vice-Presidents, B. J. Arnold, Prof. H. S. Carhart, Prof. W. E. Goldsborough, C. F. Scott, Dr. S. W. Stratton; General Secretary, Dr. A. E. Kennelly; Treasurer, W. D. Weaver, and an Advisory Committee of twenty-five.

The plans of the Committee of Organization are to invite *all interested* in electricity and its applications to accept membership in, and to attend the Congress if possible; to convene the Congress during the week set aside by the Universal Exposition for that purpose (12th to 17th September); to report the meetings of the Congress; and to publish the transactions subsequently, each member of the Congress to receive a complete copy thereof.

COLOR-CHANGES BY RADIUM RAYS.

According to Mr. W. Ackroyd, color-changes are frequently brought about by the action of radium rays. These changes have been examined by embedding a radium bromide tube in the substance experimented upon. After a few hours sodium chloride becomes orange or buff colored, potassium chloride becomes violet, but returns to its original color very quickly after removal of the exciting cause. Sodium bicarbonate and potassium metabisulphite are changed to amethyst color after twenty-four hours' exposure.—*London Nature.*

RAMSAY ON RADIUM AND HELIUM.

Sir William Ramsay, professor of chemistry at University College, London, who, with Lord Rayleigh, separated helium from the air, in a lecture before the London Institution, made the interesting announcement that his experiments with radium had shown that that element has the power of changing by some subtle process into another element, namely, helium. He described how a long search into the problem of what becomes of the minute particles with which radium is always parting was quite lately rewarded. Besides its other manifestations, radium constantly gives off an emanation which seems to behave in all respects like a heavy gas. It can be collected in tiny flasks, measured, weighed and used to display the characteristic properties of radium, but it is not permanent. In about a month it entirely disappears. The question is, "What becomes of it?" Sir William has caught this emanation in the act of vanishing. He found that after it had been collected a couple of days its spectrum, which previously was entirely unlike any yet studied, began to display the typical yellow line of helium.

In four or five days the helium grew brighter, and in another week the spectrum of helium was positively blazing in the hermetically sealed tubes that had been filled with the pure emanations or gaseous output of radium. In other words, one element had been literally seen to change into another.

This realization of one of the oldest of human dreams was, said Professor Ramsay, very suggestive of transmutation. The problem might not be actually solved, but it was by no means absurd. Professor Ramsay calculated that if radium turned into helium and nothing else it would take 2,000,000 years

to dissolve into gas; but if helium is only one of the substances given off, transmutation would be proportionally shorter. He is now investigating to learn precisely how much helium was produced from the radium, what happened in the change and how long it took. He pointed out that several groups of elements linked together by Mendeljeff's periodic law showed a remarkable similarity of properties, tending to suggest that the accepted elements were not the final forms of matter, and that they were ultimately reduced into a few simpler forms. He asked if the world was on the verge of some great generalization, showing that all the so-called elements were merely elusive forms of one or two fundamental kinds of matter.

Professor Ramsay stated that Professors Rutherford and Soddy were co-operating with him in his investigations. He incidentally remarked that the price of radium had increased ten-fold in the last six months, owing to the action of the Austrian Government, which had created a corner therein by refusing to allow further exports of refuse from the uranium oxide works at Joachimthal. As a result, the nominal price of radium is about $250,000 for one-fifteenth of an ounce.

Among a number of other interesting points the lecture showed the power of radium to make certain minerals and chemical compounds luminous. Professor Ramsay subjected a piece of the mineral willemite to the "bombardment" of radium particles, whereupon it shone brightly. In an interview after the lecture, Sir William said it was practically impossible at present to obtain more radium. It had been said that an American company had been formed to mine it, but he had tested the American ores supposed to contain it and found them absolutely worthless.—*Electrical World.*

THE PETROLEUM FIELDS OF CALIFORNIA.

The United States Geological Survey, within the last eighteen months, has been making a preliminary examination of the productive oil fields of California, with a view, first, to acquiring a knowledge of the general conditions of occurrence of petroleum in the State; and, second, to applying the laws that may be deduced from such researches to other portions of the Coast Range. The Director of the Survey has long recognized the paucity of knowledge relating to Coast Range geology, and in view of the fact that several of the formations of this region are oil-bearing he is now directing especial efforts to unraveling the intricate problems with which mining engineers, oil men, and others have to do in the prosecution of their professional and industrial work. A considerable number of topographic maps, covering the agricultural regions of southern California, have already been published—these with special reference to the water supply. Latterly other sheets of a similar nature, but covering more particularly the oil fields, both productive and prospective, have been prepared and are now in the hands of the engraver. Still others are under survey in the field. Eventually it is proposed to cover the entire area of the Coast Range, the field work to be carried on as rapidly as the resources of the Survey will permit.

Recently a member of the Survey has made an extended preliminary examination of the more productive oil fields and the territory adjacent, and it is the intention to make public this information in a report to be issued in the latter part of this year. It is the Director's desire, in the preparation of this

report, that it shall contain such facts as will be of especial service to men interested in the development of oil fields. The subject-matter of the report will therefore embrace such maps of the Survey as are available, others more on the order of land surveys, which will serve a temporary purpose, sections of the formations and structural features encountered, and the text descriptive thereof.

It may be mentioned in passing that the Coast Range of California, from a geological standpoint, is as little known as many of the more inaccessible portions of the United States. Since the surveys of Whitney little attention has been given to this important mountain system, the Sierras, richly productive in gold and silver, having absorbed the principal efforts of the geologists, State as well as Governmental. In the prosecution of the surveys in the coast ranges the work has to be undertaken from the beginning, and many general problems of geology must be worked out before satisfactory conclusions may be drawn with regard to economic problems. As nearly as possible, however, these investigations will go hand-in-hand, for no one more fully recognizes the necessity for studies of the mineral wealth of our country than the Director.

Incidentally attention is called to a recent bulletin, No. 213, of the United States Geological Survey, entitled "Contributions to Economic Geology, 1902," in which a brief account of the oil fields of California is given.

THE GYPSUM DEPOSITS OF LARAMIE PLAINS, WYOMING.

In the course of work for the United States Geological Survey, Dr. W. C. Knight has made a report on the gypsum and plaster industry in Wyoming.

The gypsum deposits of the Laramie Plains are very extensive and varied. They occur in or are associated with the Red Beds, and extend along the foot of the Laramie Mountains from the Colorado line northward for a distance of more than 60 miles In this distance there are some faults and also some slight folds which prevent the deposits from following the strike of the range.

The deposits belong to two classes, the primary and the secondary gypsum. The primary beds are located about 700 or 800 feet below the top of Red Beds. They vary in thickness from 6 to 50 feet, and usually dip to the west at an angle of less than 10°. The thickest beds are at the south end of the Plains, in the vicinity of Red Mountain. The gypsum, so far as tested, is very pure and makes a first-class plaster of paris, as well as good land plaster, and also the new kind of wall plaster in which a retarder is used and which is fast taking the place of lime in general construction work. The secondary beds are superficial or nearly so, and are composed of gypsum in a finely divided state, mixed with sand and granular carbonate of lime. These deposits occur in undrained depressions below the Red Beds, and out-crop occasionally along the entire length of the Red Beds. These secondary accumulations often cover many acres in extent, and are of exceptional value on account of the cheapness of quarrying, the dust-like condition of the product, and its superior quality. Beds of this kind are plowed, and the gypsum is carried in wheeled scrapers to the mill, where, without passing through the usual grinding machinery, it is simply put through the regulation boiler for plaster of paris, and the product is finished.

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The development of the gypsum industry has been very backward until recent years. The Red Buttes Plaster Company erected a plant at Red Buttes for the manufacture of plaster of paris about 15 years ago. On account of high freight rates and Colorado and Utah competition this plant has never worked continuously. This company quarries from 6 to 10 feet of first-class gypsum and manufactures plaster of paris and the new wall plaster in which the retarder is used. The company turns out annually from 600 to 800 tons of the various products. The development of the secondary beds is much more recent. Several years ago a large plant was erected at Laramie, and was conducted with indifferent success until it passed into the hands of the Acme Company. Since then it has been operated at full capacity, and has been marketing about 100 tons of plaster per day. The Acme Company is working a bed 9 feet deep that is located at the plant. About a foot of soil has to be removed from the surface of the deposit, and the rest of it is of the same color and grade to the bottom. This is manufactured into various kinds of plaster, but the leading brand is the "Laramie Standard Plaster," largely utilized for plastering the interior of houses. It makes a stronger plaster than lime; it is harder and stands better than any other finish for a wall.

CEMENT FROM SLAG.

In a recent United States consular report it is stated that the manufacture of cement from blast-furnace slag and limestone in Germany and Belgium has proved successful, and that negotiations are now being carried on to establish the industry in England. It is claimed that Portland cement can be manufactured more cheaply from slag and limestone than from the materials at present employed; and that, owing to the uniformity in the composition of the slag, the finished product is less liable to variations in composition, and is therefore more trustworthy. Mortar made with slag cement in the proportion of 3 parts sand with 1 part cement had a tensile strength of 383 pounds per square inch after seven days' hardening, and a strength of compression of 3,880 pounds per square inch. After twenty-eight days the strengths had increased to 551 pounds and 5,441 pounds respectively.

It will be recalled by some of our readers that the late Frederick Ransome, of London, England, was engaged for many years in the manufacture of a hydraulic cement from blast-furnace slag by a patented process, though with what success we are unable to state. The comment is made merely to indicate that the proposition to utilize this waste product for the purpose is not a new one. W.

SYNTHETIC ALCOHOL.

Some very curious, semi-industrial experiments were recently made at Puteaux in the experimental laboratory of the Compagnie Urbaine d'Eclairage par le Gaz Acetylene, in the presence of its stockholders and a few favored persons, and the object of which was to demonstrate the possibility of manufacturing alcohol by starting with the elements carbon, hydrogen and oxygen.

The problem seems to us to have been admirably solved, although there were presented to us only the problems of Berthelot, the inventor and father

of organic synthesis, the modern improvers of whose theory, however, have profited by all the discoveries of science since 1855, and particularly those of the electric furnace, electrolysis, etc.

A new carbide (?), which is presented to us as *ethylogen*, undeniably possesses the property of disengaging ethylene gas, that is to say, the synthetic nucleus of alcohol, instead of acetylene gas, when it is plunged into water. Since this carbide is decomposed by water, at the works of production itself, in gasometers identical with those employed for the production of acetylene, there is nothing to prevent the residuum from being used anew, with the addition of carbon naturally, for indefinitely reproducing the same ethylogen carbide. This, in fact, is what occurs, save some insignificant losses of metallic substances, the final expense of the operation being summed up in the addition of carbon (represented here by coke-breeze), and much electric energy, which may be furnished by waterfalls.

The ethylene gas disengaged is received in a gasometer, whence it is pumped and made to bubble through sulphuric acid contained in a series of leaden vessels. The acid absorbs the ethylene gas in producing ethyl sulphuric ether, which thus becomes the raw material from which may be obtained a host of organic products. Upon distilling it with much water, in fact, we obtain alcohol; upon distilling it with less water, we directly obtain ether; and, in causing air, or, more accurately, its oxygen, to intervene, we obtain acetic acid, acetone, and even other carburets.

In the case of alcohol and ether, the true crude materials are the coke of the carbide and the water added to the sulphuric acid, since the metallic salts and the acid (after concentration) may, so to speak, be used indefinitely. In the case of acetic acid and acetone, the air furnishes its complement of oxygen. There remains, therefore, the carbon, say in practice 440 pounds of coke-breeze, and here is the important point—electric energy obtained cheaply.

For the sake of completeness, let us add that by similar processes, now nearly perfected, it is possible to fix the nitrogen of the air in order to make of it a fertilizer richer and cheaper than the nitrates of Chili. This information may interest our numerous readers who are occupied with agriculture.

All this together constitutes the entrance of chemical synthesis into the domain of industrial practice. It is a complete evolution of chemical industry.—*Scientific American Supplement.*

LINED TUBING *vs.* SOLID METAL.

The Metal Industry says: The use of brass in furniture trimmings and similar goods is a matter which usually does not require the highest grade of material. Finish is generally paramount to everything else. Our attention was recently called to the extending use of lined tubing in this and similar trades, and we were more or less surprised to find the quality of the tubing as good as it is and admirably adapted to the uses to which it is put.

The advent of the brass bedstead in the United States is apparently responsible for the production of lined tubing, for here was a case where nothing was required except finish and the requisite strength. The early bedstead manufacturers made tubing themselves by forming brass sheet over iron pipe. This gave the requisite strength. The call for better material, however,

became loud, and the maker soon found that to produce a good material it is necessary to use a lining metal which has a smooth, cylindrical surface. Seamless drawn steel tubing is now used, and over it the brass tube is drawn so that, to all appearances, a solid brass tube is produced. We have recently seen such tubing stand all the difficult bending that could be given a seamless copper tube, and, for many purposes, such as bedsteads and show work of various kinds, it possesses every advantage of the seamless or brazed product. This tubing should supplant the electro-plated iron rod upon which a thin coating of brass has been put, as such material sooner or later rusts and becomes unsightly. Several of the brass manufacturers have begun the manufacture of a good lined tubing, and we believe that many new uses will be found for the product.

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, December 16, 1903.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 16, 1903.

President JOHN BIRKINBINE in the chair.

Present, 54 members and visitors.

Additions to membership since last report, 13.

The following nominations were made for Officers, Managers and Members of the Committee on Science and the Arts, to be voted for at the annual election, January 20, 1904, viz.:

For President	(to serve one year)	JOHN BIRKINBINE.
" *Vice-President*	(" three years)	HENRY HOWSON.
" *Secretary*	(" one year)	WM. H. WAHL.
" *Treasurer*	(" ")	SAMUEL SARTAIN.
" *Auditor*	(" three years)	JOHN GEO. COPE.

For *Managers* (to serve three years).

ROBERT C. H. BROCK,	HENRY R. HEVI,
STEPHEN GREENE,	ALEX. KRUMBHAAR,
ALFRED C. HARRISON,	C. HARTMAN KUHN,
CHAS. A. HEXAMER,	WALTER WOOD.

For *the Committee on Science and the Arts* (to serve three years).

L. L. CHENEY,	JOHN HAUG,	L. E. RONDINELLA,
JAMES CHRISTIE,	FRANCIS HEAD,	ARTHUR J. ROWLAND,
G. H. CLAMER,	CHAS. A. HEXAMER,	SAMUEL SARTAIN,
J. LOGAN FITTS,	WALDEMAR LEE,	FRANK SHUMAN,
RICHARD W. GILPIN,	JACOB Y. MCCONNELL,	F. CARPENTER SMITH,
WM. O. GRIGGS,	J. W. RIDPATH,	THOMAS SPENCER,
J. C. TRAUTWINE, JR.,	URBANE C. WANNER.	

(To serve for two years.)
J. M. EMANUEL.

(To serve for one year.)

AMOS P. BROWN, DANIEL EPPELSHEIMER, JR.,
WM. W. CANBY, JAMES S. ROGERS,
GEGRGE P. SCHOLL.

The paper of the evening was read by Mr. John M. Hartman, on "The Regulation of the Smoke Nuisance in Philadelphia."

The speaker made some brief introductory remarks on the general subject of fuels, furnaces and proper and improper methods of firing; gave some account of what has been accomplished in other places to regulate the burning of soft coal; and proceeded to narrate his experience as Chairman of a Committee of City Councils in endeavoring to frame, and secure the passage of, a satisfactory smoke-prevention ordinance.

The subject was very freely discussed by Messrs. Jacob Reese, Wm. L. Dubois, Henry G. Morris, James Christie, A. E. Outerbridge, Jr., Henry F. Colvin, and others.

The thanks of the meeting were voted to Mr. Hartman for his able presentation of the subject.

The President announced the appointments of seven members to serve as tellers of the annual election, and the meeting was adjourned.

WM. H. WAHL,
Secretary.

Committee on Science and the Arts.

(*Abstract of the stated meeting held Wednesday, December 2d, and of the adjourned meeting of December 9, 1903.*)

MR. CHAS. E. RONALDSON in the Chair.

(No. 2258.) *Convertible and Semi-Convertible Cars.* J. G. Brill Co., Philadelphia.

ABSTRACT: These inventions are covered by letters-patent to J. A. Brill (No. 623,724 and No. 691,351).

The "Convertible" car belongs to that type of car which is open at the sides to admit passengers when the cars are in use as summer cars, and having means for closing them to protect the passengers from inclement weather. In thus closing them, they are transformed into a center-aisle car, to which access is obtained from the end platforms only.

To effect this transformation the convertible cars are provided with means for closing the sides with substantial panels from the floor upwards, where they are met by glazed sash, which are drawn down from above, the panels, sash and curtains being stored in suitable pockets provided for the purpose in the roof, so that, at any time, with very little trouble they may be transformed from open cars having side entrances into closed cars having only end entrances.

In the semi-convertible type the side foot-board is omitted, there being only end entrances with cross seats and a center aisle. The panels are permanent, and the sashes, which are made unusually wide and deep, are not

removed from the cars, but may be raised and lowered at will. The permanent panels thus keep the lower part of the car always closed. When the sashes are raised the cars are practically wide open; when they are drawn down they are securely closed against wind and rain.

The report approves and commends the devices above described as ingenious and practical. The award of the John Scott Legacy Medal and Premium is recommended to be made to John A. Brill, the inventor. (*Sub-Committee*, Henry R. Heyl, Chairman; Henry F. Colvin.)

The following reports passed first reading:

(No. 2279.) *The Eletric "Buzz" Fan.* Dr. S. S. Wheeler's claims to the invention of.

(No. 2295.) *Switch-Operating Device.* George B. Conrey, Philadelphia.

(No. 2304.) *The Molecular Structure of Cast Iron.* A. E. Outerbridge, Jr., Philadelphia.

(No. 2306.) *Nut-Lock.* James Walsh, Jr., of Philadelphia.

Report No. 2164 (Parker's Steam Generator) was discussed and held under advisement.

Applicarion No. 2284 (D'Auria's proposition) was dismissed without prejudice.

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Sections.

[*Abstracts of stated meetings.*]

ELECTRICAL SECTION.—*Stated Meeting*, held Thursday, November 12, 1903, 8 P.M. Thomas Spencer, President, in the chair. Present, 30 members and visitors.

Dr. Joseph W. Richards, of Lehigh University, Bethlehem, read the paper of the evening, on "The Electrolysis of Water," discussing the subject from the theoretical viewpoint.

The paper was discussed by Messrs. Carl Hering, C. J. Reed, Thos. Spencer and the author.

Mr. H. C. Snook, manager of the Röntgen Manufacturing Company, of Philadelphia, described and exhibited a new form of mechanical interrupter for the induction coil.

Stated Meeting, held Thursday, December 10, 8 P.M. Mr. Spencer in the chair. Present, 18 members and visitors.

Dr. Richards concluded his paper on "The Electrolysis of Water." In this installment the author described a number of forms of apparatus devised for various commercial applications of water electrolysis, illustrating the subject with the aid of lantern photographs. The paper was fully discussed.

Dr. Geo. P. Scholl presented a résumé of recent progress in the Electro-Metallugy of Iron and Steel.

RICHARD P. BINDER,
Secretary.

MECHANICAL AND ENGINEERING SECTION.—*Stated meeting*, held Thursday, November 19th, 8 P.M. Mr. Henry R. Heyl in the chair. Present, 42 members and visitors

Mr. J. B. Semple, of Pittsburgh, Pa., presented a paper describing an improved projectile of his invention, which he calls the "Torch-Shell. This projectile is provided with means for automatically illuminating its path at night, thus rendering it possible to attain greater accuracy of firing, and incidentally offering numerous other advantages, which the inventor dwelt upon. The subject was illustrated with the aid of specimens, drawings and lantern photographs. It was voted to refer the subject to the Committee on Science and the Arts.

Mr. Kern Dodge followed with a paper dwelling principally on the application of the electric motor for driving machinery, and emphasized the remarkable changes which the introduction of electricity had brought about in the modern machine shop. The paper was fully illustrated with the aid of lantern projections.

D. EPPELSHEIMER, JR., *Secretary.*

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—*Twenty-fifth Stated Meeting*, held Thursday, December 3, 1903. Mr. J. W. Ridpath in the chair. Present, 45 members and visitors.

The paper of the evening was presented by Prof. Richard Zeckwer, on "Photography as an Aid to Music." The speaker illustrated his subject by a number of experiments with sensitive flames, showing the presence of sympathetic vibrations, etc. He also exhibited a number of lantern photographs made by himself, of human subjects, which demonstrated the differences of touch on the piano in playing *legato*, *staccato*, etc.; peculiarities exhibited by singers in chest and diaphragm breathing; and photographs of sound waves, exhibiting the phenomena of reflection, refraction, interference, etc.

The paper was freely discussed by Messrs. E. Goldsmith, L. E. Levy and the author. The Chairman expressed the appreciation of the meeting to the speaker for his admirable communication. Adjourned.

M. I. WILBERT,
Secretary.

PHYSICAL SECTION.—*Stated Meeting*, held Thursday, December 17, 8 P.M. Prof. Geo. A. Hoadley in the chair. Present, 24 members and visitors.

The first communication of the evening was presented by Prof. Chas. P. Matthews, Purdue University, Lafayette, Ind., on "Modern Methods in Photometry." The speaker, after giving a brief historical sketch of the subject, described the usual methods at present in vogue in lamp factories and research laboratories, and concluded by describing an improved integrating photometer, which he had devised and introduced into service

The speaker illustrated his address with the aid of a number of lantern photographs. The paper was discussed by Mr. Carl Hering, Mr. Barrett, the Chairman and the speaker.

Professor Hoadley followed with a brief communication, illustrated by lantern views, on "Osmotic Pressure," in which he reviewed the historical development of the subject, dwelling especially on the important results obtained by recent investigations. Discussed by Mr. Hering and the speaker.

The thanks of the meeting were voted to the speakers of the evening. Adjourned.

WM. H. WAHL,
Secretary pro tem.